
Final Report

Conceptual Model of Current Conditions

**EMD Chemicals Inc.
Cincinnati, Ohio**

CH2MHILL

Submitted to

U.S. Environmental Protection Agency

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1.0 Introduction

Remedial investigations and interim actions have been performed at the EMD Chemicals Inc. (EMD, formerly known as EM Science, Inc.) facility (Site) at 2909 Highland Avenue, Cincinnati, Ohio for over 20 years. Currently, corrective measures are being evaluated and will be implemented under a Voluntary Corrective Action Agreement (VCAA), executed by both the United States Environmental Protection Agency - Region 5 (USEPA) and EMD in September 2004. EMD Chemicals currently owns and operates a chemical manufacturing facility at the Site.

The purpose of this document is to provide a Site Conceptual Model (SCM) that incorporates available information into a current understanding of the Site's hydrogeology, distribution, fate, and transport of constituents of concern (COCs) in soil and groundwater, surface water and human health risk. The SCM was used to complete the Migration of Contaminated Ground Water Under Control Environmental Indicator form (CA750), assist in the evaluation of corrective measures for the Site, and to facilitate decisions regarding ground water monitoring on and off of the facility..

A draft CMCC was submitted to USEPA in March 2005 to support submittal of the CA750 (also submitted to USEPA in March 2005). This document incorporates subsequent investigations and conclusions performed after the Draft CMCC submittal to address comments from the USPEA on the initial CA 750 submittal/Human Health Risk Assessment Addendum submittal, and additional data to determine current conditions related to off-site risks to construction workers.

1.1 Site Conceptual Model Summary

The Site is used for the industrial manufacturing, storage, and distribution of organic and inorganic chemicals and has served in this capacity since the late 1940s. Areas with actual or potential releases, identified as Solid Waste Management Units (SWMUs) and Areas Of Concern (AOCs), were mitigated or addressed by 1988 with the majority of actual releases mitigated in the 1980s.

A plan view of the Site showing the conceptual model of groundwater contamination fate and transport is presented as Figure 1-1, Groundwater Plume Capture Modeling. Environmental samples were collected from soil, groundwater, and surface water (including storm sewers) both on-site and off-site to develop a clear understanding of the area that may have been impacted by site-related chemicals, the movement and fate of those chemicals, and to provide data for this model. The vertical and horizontal extent of Site-related chemicals has been defined. The impacted area extending offsite is located beneath an interstate highway and railroad transportation corridor and does not impact residential or other commercial/industrial land owners.

The geology is complex, consisting of discontinuous sand and gravel within predominantly glacial and lacustrine silt and clay deposition. Perched groundwater within these units flows to the southeast and is separated from an underlying regional aquifer by a series of confining units (aquitard units). The flow rates observed through environmental testing and sampling efforts are very low in perched ground water beneath the Site, and extremely low off of the Site. The primary constituents of concern (COCs) at the Site are Volatile Organic Compounds (VOCs), including chlorinated VOCs, BTEX compounds (benzene, toluene, ethyl benzene, and xylenes), and 1,4-dioxane.

The area where soil is impacted by COCs is limited to the central and south-central portions of the Site below former source areas and a small area immediately off-site associated with overland flow from West Ravine drainage. Like the groundwater, vertical contaminant distribution in soil is limited to the top of the uppermost aquitard unit. Perched groundwater impact covers approximately two-thirds of the Site and a downgradient, off-site area to the southeast. Through an evaluation of the data over time and over distance, natural attenuation is observed to be decreasing the contaminant mass in both on-site and off-site areas. This impacted groundwater is intercepted by existing interim measures (further reducing contaminant mass), backfill material surrounding a 96-inch storm sewer to the east; and by the backfill material containing the Duck Creek concrete conveyance system to the southeast. Storm sewer backfill sampling along and downgradient of where the plume intersects the sewer indicate a decrease in concentration to below reporting limits in the direction of water flow. At the downgradient end of the flow system, where the Duck Creek box culvert discharges to an open concrete ditch, there are no detections in surface water. Concentrations within the box culvert backfill (under this discharge point) have been evaluated using sample results and modeling. The backfill contaminant concentration was estimated at non-detection (for chlorinated VOCs and BTEX) and near published U.S. EPA, Region 9 preliminary remediation goals (PRGs) for 1,4-dioxane in tap (drinking) water. The validity of the model was confirmed by the collection of two additional grab groundwater samples in October 2005. A technical memorandum summarizing this investigation was submitted to USEPA in December 2005.

Based on the data generated during investigations performed at the Site (referenced in this document) and supplemented by the hydrogeologic model/confirmation data presented in this document, the migration of contaminated groundwater is under control.

A Human Health Risk Assessment Addendum (CH2M HILL, 2006) performed using historical data indicated that there was the potential for risks higher than the U.S. EPA risk reduction goals associated with potential on-site and off-site construction worker contact with soil and groundwater. However, the off-site potential health risks were calculated using soil samples collected from two locations in 1997. Those two soil sample locations were re-sampled in May 2006 and the risk calculations were revised. As documented in the Human Health Risk Addendum for Off-site Soils (CH2M HILL, 2006b), there are no unacceptable off-site human health risks above risk based goals.. The only remaining risks are potential on-site risks for the construction worker scenario completing excavation activities and for indoor air vapor inhalation.

The ecological risk evaluation determined that overall the potential for ecological risks at the Site, either at on-site or off-site locations is negligible. The presence of ecological receptors and supporting habitat is very limited because of the industrial use of the facility. Potential ecological exposure pathways at off-site locations are also very limited due to the comprehensive array and use of the transportation corridor and the enclosure of Duck Creek in a twin concrete box culvert beneath the corridor.

2.0 Site Background

2.1 Work Performed To Date

Voluntary Actions Taken by EMD

In the 1980s and early 1990s, EMD voluntarily addressed potential areas that may contribute to off-site migration of COCs by installing Interim Measures until final corrective actions could take place (see Section 2.3).

OEPA Administrative Order on Consent Activities

The effort to complete the environmental assessment of the Site and move forward to final corrective actions was formalized under an Administrative Order on Consent (Order) signed by the Ohio Environmental Protection Agency (OEPA) and EMD in 1992. The Order required completion and submittal of an OEPA approved Remedial Investigation (RI) prepared by The Payne Firm, Inc. (TPF) (TPF, 1996) and Feasibility Study (FS) (OEPA, 2004). Technical Memoranda, Technical Amendments and Work Plans detailing specific issues or investigations performed to support the RI and FS, were prepared and submitted to OEPA.

Interim Measures continued with additional improvements to the storm water management system, installation of a ground water pumping well (P6A), assessment and removal of mercury impacted soils, and installation of additional Site security fencing (OEPA, 2004).

The draft Human Health EI (CA 725) was completed and submitted to the OEPA. The OEPA executed the document on April 20, 2002 with a RCRIS code of YE – Current Human Exposures Under Control.

The RI was determined to be complete and approved by the OEPA in 1996. The FS, identifying potential final corrective actions, was determined to be complete and approved by the OEPA in 2004, satisfying the Order signed in 1992.

Voluntary Corrective Action Agreement Activities

The following actions were completed under the authority of a VCAA executed between EMD and the USEPA on September 23, 2004:

Environmental Indicator CA 750 Completion

Draft Migration of Contaminated Groundwater Under Control Environmental Indicator (CA750) report was submitted to U.S.EPA in March 2005. Confirmation groundwater samples in support of the CA750 were collected in October 2005 and reported in a December 2005 technical memorandum (CH2M HILL, 2005b). Based on this data, the U.S.EPA indicated in April 2006 that the report would be accepted;

Human Health Risk Assessment Addendum

The Human Health Risk Assessment Addendum to the 1996 baseline risk assessment (included in the 1996 RI Report) was initially submitted to the USEPA in March 2005.

Comments were received by EMD from USEPA in October 2005, the comments addressed to the satisfaction of USEPA, and the report finalized in January 2006 (CH2M HILL, 2006). Additional investigations were performed in May 2006 to assess the current conditions with respect to off-site risks to construction workers identified in the risk assessment addendum. As a result, the risk assessment addendum was updated via a technical memorandum that demonstrated risks to off-site construction workers do not currently exist (CH2M HILL, 2006b). The technical memorandum was included as an update package to the risk assessment addendum with this final CMCC in June 2006.

Update to Post RI/FS Investigations Report

A document entitled Update to Post RI/FS Investigations Report (UPI Report, TPF, 2005), presenting investigations performed in support of the on-going corrective action process, was finalized in March 2005 and is supplemented by annual reports to the USEPA summarizing all field activities and data collected during the year.

Preparation of Draft Corrective Measures Proposal

The final proposed corrective actions chosen for this site are detailed in the Draft Corrective Measures Proposal submitted with this final CMCC in June 2006.

2.2 Status of SWMUs/AOCs Investigated

Eleven SWMUs and two AOCs were identified by USEPA during the Preliminary Assessment/Visual Site Investigation (PA/VSI, USEPA, 1990). The current statuses of the SWMUs/AOCs were re-assessed as required by the VCAA and submitted to the USEPA on December 22, 2004 (CH2M HILL, 2004); the results are presented in Appendix I(D) of the UPI Report (TPF, 2005). SWMU/AOC locations are shown on Figure 2-1.

SWMUs 6 through 10 were investigated via soil and groundwater sample collection and analyses during the RI (TPF, 1996). SWMUs 6 through 9 are related to past Site operations where releases of chemicals occurred that may have contributed to soil and groundwater contamination beneath and off of the Site. Chemical wastes from some of these SWMUs were reportedly routed via drains to the West Ravine during historical operations. Discharges to the West Ravine from these SWMUs were mitigated between the 1950s to the early 1980s. The former Tank Farm (SWMU 8) was taken out of service in 1988 and removed in 1990, and replaced by a newly constructed Tank Farm located on the east-central portion of the Site.

SWMU 10 consists of the West Ravine leachate and storm water collection sump area (Sump 562), installed to capture leachate and drainage from the West Ravine. The West Ravine was a surface water erosional feature that was filled in stages with varying fill material as the Site was developed between the 1950s and early 1970s. The northwestern portion was filled with soil and construction debris. The central and southeastern portion was filled with soil and construction debris, off spec chemical waste containers including glass bottles, and debris from a 1960 building fire. The last containers were placed in the West Ravine in the early 1970s; therefore non-glass containers most likely would have already corroded enough to release contents, if any. A 16-inch clay pipe sewer, which was constructed in sections as the ravine was filled, drains the base of the fill material in the West Ravine. The 16-inch pipe

discharges to Sump 562 during normal flows. Periodic sampling of the discharge water from the 16-inch pipe during investigations performed at the Site have not detected any “spike” in contaminant concentrations (TPF, 2005)

The remaining SWMUs and AOCs did not require investigation during the RI. These SWMUs are either active units related to current facility operations, closed, or will be closed during final corrective measures (CH2M HILL, 2004). Since 1988, releases or potential releases due to facility operations have been mitigated by EMD through upgrading systems (as previously discussed) and following procedures, and practices developed in accordance with EMD’s Health, Safety, Security, and Environment directive. Details of SWMU history and current status are presented in the RI (TPF, 1996) and Appendix I(D) of the UPI Report (TPF, 2005).

2.3 Interim Measures

Active remedial interim measures installed in the 1980s were evaluated in 1994 for effectiveness. The evaluation was presented in the Interim Action Efficacy Report (TPF, 1994a). Additional soil removal interim measures enacted in the late 1990s are detailed in the Feasibility Study (OEPA, 2004).

2.3.1 Sump 562

Sump 562 was installed in 1983 at the mouth of the West Ravine to intercept and collect impacted storm water and leachate (including “Seep 562” effluent) previously flowing from the former West Ravine area to the ground surface and downstream storm water drainage features. Since completion of Sump 562, improvements have been made to the initial design to increase capacity and efficiency. Sump 562 was found to be effective at meeting its design requirements (TPF, 1994a).

2.3.2 French Drain

Installed between 1987 and 1988 into the saturated Upper Sand unit (see Section 4.2.1), the French Drain runs from the northern portion of the property beneath the new tank farm to the south and terminates east of Building 14 (TPF, 1994a). The French Drain’s designed purpose is to intercept and collect impacted groundwater migrating locally to the east and southeast through the Upper Sand unit. The French Drain system was found to be effective in relation to its design purpose (TPF, 1994a). Subject to monthly inspection and measurement of up- and down-gradient groundwater elevation contours, the French Drain remains in service with improvements and modifications to the original design.

2.3.3 Storm Water Management Program

To prevent infiltration into possibly impacted soils and to reduce infiltration of storm water into the former West Ravine, a storm water management system was installed in 1987 to direct storm water (unimpacted by facility operations) from facility process areas to off-site storm sewer systems (TPF, 1994a).

2.3.4 Well P6A

Extraction Well P6A was installed in 1992 into the sandy silt portion of the Lower Clay unit (see Section 4.2.1) to intercept impacted groundwater flowing eastward under the French Drain system. P6A was demonstrated as effective in controlling the hydraulic gradients in the sandy silt portion of lower clay east of the French Drain system and in reducing the mass of contaminants in this portion of the Lower Clay unit (TPF, 1994a). In 1997 pumping from the well was discontinued due to non-detection of contaminants in the groundwater being captured (OEPA, 2004).

2.3.5 Security Fencing

Security fencing was installed and tied into the Site's existing security fencing in January 1996 to prevent unauthorized access to impacted materials at the mouth of the West Ravine. A 24-hour guard is posted at the Site's main gate, and no unauthorized access has been noted at the Site (OEPA, 2004).

2.3.6 "Hot Spot" Assessment and Removal

In 1997, areas of impacted soil that may carry an unacceptable risk of exposure were assessed and where necessary, managed. Four cubic yards of mercury impacted soil were removed to an off-site permitted disposal facility. Through additional sampling and risk evaluation, a localized area of PCB impacted surficial soils was determined to pose no unacceptable risk. Action on an area of VOC impacted soils located beneath the former Tank Farm area east of Building 4 was deferred to the FS and Remedial Action phases of Site management (OEPA, 2004).

3.0 Land Use

3.1 Current Site Conditions

The Site is an operating industrial facility involved in chemical manufacturing. Current and expected future use of the Site is as an industrial property. The municipal boundary between the cities of Norwood and Cincinnati runs north-south near the east-central part of the Site with approximately 95% of the operational portion of the Facility within the City of Norwood. Zoning for the Site within the Cincinnati municipality is "MG Manufacturing General" and within the Norwood municipality is "M-2 Heavy Manufacturing" Details of the zoning designation and applicable ordinance are presented in a document (CH2M HILL, 2004a) that is included in Appendix I(C) of the UPI Report (TPF, 2005).

3.2 Surrounding Land Use

The Site is located in an area that predominantly consists of commercial and industrial land use, for at least a one mile radius from the Site, with some residential land use mixed in (Figure 3-1). West and north of the Site predominantly are areas of industrial manufacturing, warehousing, chemical production, and service companies. One residence is located northwest of the Site along Highland Avenue. Immediately beyond the Norfolk Southern railroad embankment to the east, the topography slopes steeply to Duramed Pharmaceutical, Inc. south of the Site, an interchange between State Route 562 (SR 562) and Interstate-71 (I-71), consisting of the Norwood Lateral road and associated on- and off-ramps, separate the Site from I-71. The SR 562 interchange also separates the Site from a residential area located 500 feet southwest of the Site. The area impacted by site-related chemicals is the facility itself (industrial land use) and the highway and railroad transportation corridor.

3.3 Water Wells

According to the City of Norwood and the Ohio Department of Natural Resources, groundwater use for non-potable purposes in the vicinity of the Site is exclusively pumped from the Norwood Trough Aquifer (NTA). There are no wells in the NTA that are currently used for drinking water purposes, and there are no production or private wells within the perched ground water (Update to RI/FS Well Search; TPF 2005). Currently, within a one-mile radius of the Site, there are five active production wells for industrial process water use screened in the NTA, with several inactive or abandoned wells (see Figure 3-2).

Groundwater pumped from the NTA in this area is used solely for industrial process water; no water derived from the NTA is used for drinking purposes by the City of Norwood or private industry. The RI and UPI found that drinking water is supplied to the City of Norwood by the City of Cincinnati, and no private residential wells are screened in the NTA or in perched groundwater above the (TPF 2005).

Installation of private potable water wells in the vicinity of the Site is governed by Ohio Administrative Code Rule 3701-28-10 which promulgates rules regarding the proximity of the well to known groundwater contamination and well construction restrictions. Based on the cited rule, it is unlikely that the local health department would approve the construction of a potable water well within the perched zone system in the vicinity of the EMD site but would likely require a potable water well to be completed in the lower portion of the Norwood Trough Aquifer. Additionally, it is unlikely that anyone would attempt to construct a potable water production well in the off-site perched zone system that is impacted by Site related COCs since such a well would not yield groundwater in sufficient quantities or quality for potable water use. Therefore, future use of contaminated perched ground water in the vicinity of the EMD facility for potable water use that could be impacted by Site related COCs is unlikely to occur (TPF, 2005).

4.0 Current Hydrogeologic Conditions

Groundwater flow both on-site and off-site is characterized as a perched groundwater system, as opposed to an aquifer, due to its inadequate yield to support potable or non-potable groundwater production or use. Flow is controlled by the permeability of and disposition between:

- Surficial fill materials,
- Native geologic units, and
- Backfill of sewers.

4.1 Anthropogenic Changes During Area Development

The Site is situated across a couple of former tributary drainage ravines (i.e. West Ravine and East Ravine) to the Duck Creek valley southeast of the Site (Figure 4-1, Anthropogenic Changes to Site Area Since 1912). The West and East ravines were filled during the course of Site expansion and property development in the area that occurred prior to EMD owning the site from the 1930s through the 1970s (TPF, 1996). In general, the following occurred at and immediately adjacent to the Site:

- Site-wide fill beneath the buildings, roadways, and open areas was emplaced and consists of 3 to 5 feet of non-engineered fill.
- During the 1970s, the East Ravine was filled with soil and limited pieces of construction debris; no chemical waste was buried in the ravine. Before the ravine was filled, a concrete storm sewer was constructed by the Metropolitan Sewer District (MSD) at the bottom of the ravine with 96-inch and 84-inch sections. The 84-inch sewer section was extended to the Duck Creek box culvert located south of the Site. This sewer is collectively referred to as "the 96-inch storm sewer" in this document.
- From the 1950s to the early 1970s, the West Ravine was filled in stages with varying fill material as described in Section 4.2.1. During this time period, a 16-inch clay tile storm sewer was constructed in sections at the bottom of the ravine; the storm sewer currently terminates at the Outfall located at the end of the ravine.
- The grading fill material used in the construction of the Norfolk and Southern Railroad embankment located east-southeast of the Site is of an unknown type. Boring logs indicate that it is primarily fine-grain clay with some sand and gravel content. Construction of the railroad embankment east of the Site cut across the end of the East Ravine in the 1930s. In addition, construction of the railroad embankment likely cut down the "nose" of the ridge of native geologic material between the East and West ravines, with any displaced soil possibly being used for fill in the ravines and other topographically low areas.
- The fill associated with the Ohio Department of Transportation (ODOT) properties beneath SR 562 and I-71 interchange consists of engineered fill, soil, and construction debris.

- The Duck Creek twin box culvert to the south was constructed by ODOT within a sand backfill trench along the base of the former Duck Creek drainage during emplacement of the I-71/SR 562 interchange in the late 1960s. The storm sewer to the east of the Site, consisting of both 96-inch/84-inch diameter sections (discussed above), was constructed within a mix of native geologic material and sand backfill material along the base of the East Ravine and connects to the Duck Creek box culvert.

4.2 Hydrogeology

4.2.1 Groundwater Occurrence

The shallow units bearing perched groundwater, from ground surface to the top of the underlying aquitard units, consist of 30 feet (at Duck Creek) to 70 feet (on EMD property) of silt, clay, sand and gravel of glacial, lacustrine and glaciofluvial deposition origin (TPF, 1996). Cross sections of the geologic units and occurrence of groundwater across the Site are provided on Figures 4-2 through 4-4. Varying degrees of flow exist in the Fill through Lacustrine-2 units due to the discontinuous nature of sand and gravel distributions within the predominantly silty clay deposition. Overall the rate of flow is too low (below 7×10^{-5} centimeters per second, or 0.2 feet per day) for ground water use. Groundwater occurrence per unit is summarized below:

- Fill: The fill within the West and East Ravines is discontinuously saturated, with screen elevations higher than those in the lower perched units due to the separate perched nature of the ravine-fill groundwater. A 16-inch clay pipe sewer drains the base of the fill material in the West Ravine and discharges to Sump 562 during normal flows. The 96-inch storm sewer drains the base of the fill material in the East Ravine.
- Upper Till Unit with Sand Seams: Silty clay matrix containing varying amounts of sand and gravel, with thin (less than 2 feet) interbedded, discontinuous sand seams. Some sand seams appear hydraulically isolated while others appear hydraulically connected. In general, monitoring wells are purged dry during sample collection.
- Upper Sand Unit: Sand and gravel with silt and clay; 0 to 7 feet thick across the Site thinning from north to south, outcropping into the West and East Ravines, and terminating at the southern property boundary (Figure 4-4). Primarily saturated; however, the southeastern portion of the unit is dry where it is cutoff from recharge downgradient from the French Drain (see Figure 4-2) which dewater this unit.
- Lacustrine-1 Unit: Varved silt and clay deposits interbedded with discontinuous silt and silty sand seams. The silt and sand seams are thicker (1 to 6 inches) and more prevalent downgradient off-site and in the southern portion of the Site. The silt and sand seams are non-existent in the far-southeastern portion of the Site. This absence of silt and sand seams extends off-site to the east of the southeast corner of the site and results in lower groundwater transmission rates than the remainder of the unit containing silt and sand seams. Beneath the eastern portion of the Site, this unit pinches out into the sandy silt lower clay erosion/depositional feature in the East Ravine area (Figure 4-2). The majority of monitoring wells in this unit purge dry during sample collection.
- Lower Clay Unit/Lower Sand Unit: An irregular depositional unit consisting of multiple soil types (Figure 4-5, Lower Clay Unit Erosional Features) including:
 - Sand and gravel in the central portion of property;

- Silt to fine sand predominantly in the northeast portion of the Site;
- Sand and gravel in a silty clay matrix in the northwestern and southern portions of property.

The central and northeast gravel and silty sand portions are separate erosional features within the remainder of the silty clay unit (Figures 4-2, 4-3, & 4-4). Extraction well P6A is completed within the silt to fine sand portion of the unit. In general, monitoring wells in central and northeast portions produce water in limited quantities, while those in the southern and off-site portions purge dry during sample collection with recovery periods on the order of days to weeks.

- Lacustrine-2 Unit: Varved silt and clay deposit, 1 to 3 feet thick. Present over central and southern portions of the Site and off of the Site, but absent beneath the north and northeast portions of the Site. This unit is not thick enough to solely support wells, but it is likely hydraulically similar to the Lacustrine-1 unit.

Beneath the perched groundwater system is a sequence of low-permeability units that serve as an aquitard (TPF, 1996), preventing downward migration of perched groundwater:

- Lower Till Unit: Lean clay with sand and trace gravel. Thickness ranges from 12 to 31 feet, thinning to the south. Dry (as observed by monitor wells completed in the unit), serving as a primary confining unit throughout the study area and extending past the 96-inch storm sewer and Duck Creek storm water conveyance systems. The RI reported the mean vertical hydraulic conductivity in the Lower Till Unit is approximately 3.4×10^{-8} cm/s.
- Lacustrine-3 Unit: Similar to Lacustrine I and II units. No saturated sediments identified.
- Norwood Trough Sand and Gravel: This upper portion of the Norwood Trough unit consists of 70-90 feet of unsaturated silt, sand, and gravel deposits which are partially cemented. One boring (LT203) penetrated into this unit, with vertical hydraulic conductivities on the order of 1×10^{-7} cm/s. This portion serves as an aquitard but also as a confining unit of the underlying Norwood Trough Aquifer.

Underlying the aquitard unit sequence is the regional Norwood Trough Aquifer (NTA) and bedrock (TPF, 1996):

- Norwood Trough Aquifer: Consisting of sand and gravel. This lower portion of the Norwood Trough unit is a saturated aquifer approximately 75 feet thick and appears to be confined based on a drill stem test performed during the RI investigation (TPF, 1996). No Site wells penetrate into this saturated unit.
- Bedrock: Unsaturated interbedded shale and siltstone that lies beneath the NTA

4.2.2 Groundwater Flow

Figure 4-6, First Water Contour Flow Map, shows the contour map of elevations of the uppermost occurrence of perched groundwater in naturally deposited units (due to the on-site to off-site pinch-out of units) and sewer backfill, excepting the separate perched groundwater within the West Ravine Fill (which is not indicative of subsurface groundwater flow in the vicinity of the West Ravine due to the nature of fill in the West Ravine). The groundwater gradients range from 0.01 feet per foot (ft/ft) on-site and near the Duck Creek box culvert to 0.13 ft/ft on the south side of the EMD property and across the

French Drain. The general groundwater flow direction is to the southeast across the EMD property and off-site, with several local flow components:

- Groundwater mound at MW31A/B located just south of Building 10.
- Two separate flow paths from the property area: 1) east toward the French Drain (upper Till and Upper Sand units) and below the French Drain (Lacustrine and Lower Clay units) toward the 96-inch storm sewer; and 2) southeast from the West Ravine area toward the Duck Creek box culvert.

The groundwater divide into east and southeast components is due to both man-made and geologic features:

- The railroad fill cuts off the Upper Till and a portion of the Lacustrine-1 units (Figure 4-3),
- Silt or sand seams have not been identified in the Lacustrine-1 and Lower Clay unit in the area immediately adjacent to the southeast corner of the Site (Figure 4-3),
- The Lower Clay unit transitions from sand/sandy silt units to silty clay near the southern end of the French Drain and continuing to the south towards Duck Creek (Figure 4-5), providing on-site groundwater paths of least resistance through the sandy Lower Clay unit to the east or around the railroad fill through the Lacustrine-1 unit to the southeast.

To the southeast near Duck Creek, groundwater appears to flow into the upper portion of the Lower Clay Unit from the pinch-out of the Lacustrine 1 unit (Figure 4-4). However, flow into the Lower Clay is likely restricted due to the low hydraulic conductivity of the unit.

4.2.3 Groundwater Discharge

On-site and downgradient from the Site, groundwater discharges to either interim measure collection systems or the backfill of storm sewers that were installed in natural drainage features (former Duck Creek and East Ravine drainage systems), depending on the flowpath. The Fill, Upper Till, and Upper Sand groundwater flow to the east is intercepted by the French Drain and to the southeast partially by the West Ravine 16-inch clay pipe/Sump 562 with non-intercepted flow continuing southeast. The Lacustrine and Lower Clay (sand portion) groundwater flow to the east is intercepted by the 96-inch storm sewer backfill, while off-site flow through the fill, Lacustrine 1 and Lower Clay units to the southeast is intercepted by the Duck Creek box culvert backfill. Groundwater flowing from the northeast and northwest (that has not migrated through the Site) also discharges to the backfill of the Duck Creek and 96/84-inch storm sewer respectively.

Some groundwater seeps have been observed discharging into the 96-inch storm sewer and Duck Creek concrete conveyance systems through cracks or joints in the structures and are currently or have been monitored during sampling events (TPF 1996, 2005). However, these seeps exhibit extremely low flow (approximately 40 ml/2 minutes based on sample collection). Both of the conveyance systems maintain a base flow of water that rapidly increases during rainfall events. The Duck Creek twin box culvert has an inflow and outflow at each end of the culvert where the Duck Creek stream channel enters and exits the culvert. These locations were also monitored during VCAA UPI quarterly sampling events (TPF, 2005) that will continue quarterly until the installation of corrective measures. At that time, the monitoring plan will be revised.

4.3 Site Specific Parameter List Development

Initial Site sampling during the early stages of the RI included the list of analytes from 40 CFR 264 (US Code of Federal Regulations), Appendix IX and radionuclides (TPF, 1996). Initial RI investigations focused on sampling the SWMUs/AOCs and the West Ravine area to determine the site-specific parameter list (SSPL), also referred to as in other documents as the site target analyte list (TAL). Through assessment of the analytes actually detected at the Site and site-specific knowledge (i.e., chemicals either not used or not known to be present at the Site), the list of constituents to be included in the SSPL for additional assessment was limited to those requiring further assessment in the later stages of the RI.

Specific exclusions of Appendix IX compounds and radionuclides from inclusion in the SSPL were based upon the following:

- Pesticides, herbicides, and radionuclides were not included in the SSPL based on Site knowledge, low detects, and background concentrations.

The post RI SSPL was modified excluding additional compounds from future sampling events based upon the following:

- Results of the Baseline Risk Assessment pared out semi-volatile organic compounds (SVOCs) and polychlorinated biphenyls (PCBs); Dioxins/Furans were excluded from the modified SSPL based on regional anthropogenic concentrations.

Groundwater sampling performed during UPI activities for the VCAA included verification that conditions had not significantly changed since the completion of the RI (TPF, 2005). Starting in 2003, a few quarters of groundwater samples were collected from selected groundwater monitor wells and analyzed for VOCs, SVOCs and selected total and dissolved metals. Monitoring results verified that VOCs were the only constituent of concern in groundwater requiring continued assessment to support CA750 determination and corrective measures evaluations (TPF, 2005).

In the Human Health Risk Assessment Addendum (CH2M HILL, 2006) SVOCs and metals were dropped from further consideration as a risk driver (and need for future assessment or remedial action) based on screening levels and background concentrations observed during RI/FS sampling activities, leaving VOCs as the primary risk driver.

The SSPL, including subsequent modifications, was used for the later portions of the RI investigations and was referenced in subsequent analytical plans and risk assessments (TPF, 1994b, 1996, and 2005). Figure 4-7 presents an outline of SSPL development throughout the investigative process.

4.4 COCs in Soil and Groundwater

The COCs in soil and groundwater primarily driving risk are the following VOCs:

- Chlorinated compounds – CVOCs (primarily methylene chloride, trichloroethene, tetrachloroethene, vinyl chloride, chloroform, carbon tetrachloride);
- Benzene, toluene, ethylbenzene, total xylenes (BTEX); and
- 1,4 – dioxane.

4.4.1 Extent in Soils

Soils containing VOCs are primarily limited to the central and southern portions of the Site within the Fill through Lower Clay units as shown in Figure 4-8 Distribution of Constituents of Concern in Soil (TPF, 1996). These locations are proximal to historical sources of contamination noted as SWMUs 6 through 10 in Section 2.2. SVOCs and metals are largely confined to the fill or upper few feet of the Upper Till unit (TPF, 1996 and 1997b).

4.4.2 Fate and Transport in Soils

VOCs have not migrated extensively in soil away from the source areas, as demonstrated by the steep concentration versus distance gradients presented in Figure 4-8. At the mouth of the West Ravine, VOC impacts in soil are likely the result of a period of time (estimated to be between removal of a 36-inch storm sewer during highway construction in the late 1960s and the installation of Sump 562 in 1983) when discharge from the 16-inch clay pipe and subsequent overland flow (with subsurface infiltration), prior to flowing into the 27-inch storm sewer. The over flow issue was addressed as part of the interim measures at the Site.

4.5 COCs in Groundwater

The distribution of COCs in the perched groundwater on- and off-site is presented in Figure 1-1 (TPF, 1996 and 2005). In general, the primary COC plume, which contains some or all VOC groups (CVOCs, BTEX, and 1,4-dioxane), is smaller in extent than the plume based solely on 1,4-dioxane. This is especially true in the southeast area downgradient from the Site. Additionally, little to no toluene, ethylbenzene, and total xylenes have been detected in groundwater samples collected during recent quarterly monitoring events and are primarily limited to on-site monitor wells (TPF, 2005 inclusive of annual updates following completion of the UPI document).

The current understanding of the distribution of COCs in groundwater, based on the groundwater flow directions discussed in Section 4.2.2, is summarized as:

- Upper units contaminant groundwater flow toward the east onsite in the Upper Till and Upper Sand groundwater is intercepted by the French Drain (TPF, 1994a and 1996).
- Lower units contaminant groundwater flow toward the east in the Lacustrine-1 into and through the Lower Clay unit (which includes the sandy silt sub-unit in the northeastern portion of the site) is intercepted by the 96-inch storm sewer (see Figure 4-2).
- Off-site groundwater contamination is not present between the eastern and southeastern components of flow (see Figure 1-1) due to the predominance of low-permeability silts and clays in this area and within the railroad fill. Variability in composition of the Lacustrine-1 and Lower Clay units creates a preferential path for groundwater contaminants to migrate around this area (see Figure 1-1).
- For contaminant flow to the southeast, groundwater flow in the Upper Till and Upper Sand is intercepted by the West Ravine and then either by Sump 562 via the 16-inch clay pipe or continues to flow beneath the sump at the Fill basal contact with the Lacustrine-1 unit.
- Contaminant flow to the southeast in the Lacustrine- unit travels off-site with the highest concentrations observed in the area of the West Ravine with lower concentrations observed to the west.

- CVOC/benzene concentrations decrease downgradient of the West Ravine mouth to levels approaching MCLs or non-detect before coming into close proximity to backfill of the Duck Creek twin box culvert with 1,4-dioxane concentrations remaining above U.S.EPA, Region 9 Preliminary Remediation Goals (PRGs).
- To the southeast near the Duck Creek conveyance, 1,4-dioxane appears to flow into the upper portion of the lower clay unit from the pinch-out of the Lacustrine 1 unit (Figure 4-4).
- 1,4-dioxane and any remaining low concentrations of other COCs are intercepted further downgradient to the southeast by the backfill of the Duck Creek concrete conveyance system; no COCs were detected on the south side of this feature.
- No COCs were detected in surface water samples collected during the investigations from the outflow of the Duck Creek concrete conveyance system or from seeps inside the system (TPF, 2005).

4.5.1 Current Fate and Transport in Groundwater

4.5.1.1 Mass Reduction and Natural Attenuation

There have been no additions to the mass of contaminants in soil and groundwater since the mitigation of known or potential releases occurred on the Site in 1970s and early 1980s (Section 2.2). In addition, the mass of contaminants in groundwater are being reduced due to the Interim Measures (Section 2.3) and natural attenuation.

Based on a screening level assessment, biological natural attenuation of CVOCs is occurring in the perched groundwater at the Site (TPF, 1997a and OEPA, 2004). Reducing conditions prevail with the primary biological attenuation occurring through co-metabolism as CVOCs are degraded through various steps by biological processes with BTEX acting as electron donors. This is more prevalent west of the French Drain (and in transport southeast from the property) due to the BTEX supply being cut off by interception in the Upper Sand unit. Although 1,4-dioxane is not actively biodegraded, other mechanisms, such as dispersion and interception, are active controlling factors for fate and transport at the Site.

4.5.1.2 1,4-Dioxane Transport

There are a number of reasons why 1,4-dioxane is the most widely-distributed COC in groundwater (compared to CVOCs and BTEX compounds):

- It is infinitely soluble in water.
- It does not readily volatilize.
- It is not readily biodegraded.
- It has a low propensity for retardation.

These physical properties allow 1,4-dioxane to move at approximately the same velocity and direction as groundwater flow, acting like a dye tracer thus showing the direction of groundwater flow and subsequent contaminant migration pathways from on-site to off-site receptors.

4.5.1.3 Groundwater Plume Capture Modeling

Capture modeling was performed, using groundwater volume flow system estimates coupled with mass flux calculations, to determine the fate of COCs in groundwater being intercepted by the backfill of the 96-inch storm sewer and Duck Creek Concrete conveyance

systems. The results of modeling are presented on Figure 1-1; a summary of the processes used to perform the modeling are presented in Appendix B.

Migration Towards the East to the 96-inch storm sewer backfill

TCE and 1,4-dioxane were modeled since they were the highest concentrations detected. Inputs to the model included: COC concentrations, slug and pumping test results, and groundwater gradients from the Fill and Lower Clay unit monitoring wells near the sewer, as well as the assumed hydraulic conductivity and groundwater gradient within the sewer backfill (using MW18). The volume of groundwater discharged to the fill from the west side (COC influx), the east side, and flow through the backfill from upgradient of the Site (clean water influx) were used to estimate concentration changes due to dilution. Model calibration was performed using the concentrations detected in groundwater samples collected from MW-23, MW-18 and MW-506.

The model predicted that the concentrations of modeled COCs would be below method detectable levels at MW-506. COCs have not been detected in groundwater samples collected from MW-506 during subsurface investigations performed at the Site, thus confirming the model results. This calibration technique was then applied to determine the fate of the southeast plume at the Duck Creek concrete conveyance.

A seep in the 96-inch storm sewer (denoted as Sewer C on Figure 1-1) sampled during monitoring events has yielded detectable concentrations of COCs. As discussed in Section 4.2.3, seep flow is extremely low and is diluted by the base pipe flow through the 96-inch storm sewer and the flow through the Duck Creek concrete conveyance system (into which the 84-inch section discharges). As discussed in Section 4.5.1, detectable concentrations of COCs at the outfall of the Duck Creek concrete conveyance system have not been observed during monitoring events (TPF 1996, 2005).

Migration Towards the Southeast to Duck Creek box culvert backfill:

As indicated in Section 4.5.1, the concentrations of 1,4-dioxane detected in groundwater samples collected near the Duck Creek concrete conveyance system are on the order of 1 to 100 times higher than other COCs in this area. Therefore, only 1,4-dioxane concentrations were modeled.

Inputs to the model included:

- Detected concentrations of 1,4-dioxane detected in groundwater samples collected from monitor wells MW-510 A&B and temporary monitor well VE-532;
- Slug test results from monitor wells MW-510A&B;
- Groundwater gradients from the Fill and Lower Clay unit monitoring wells near the box culvert;; and,
- Assumptions of hydraulic conductivity and groundwater gradient within the box culvert backfill (derived from the temporary well VE532).

The model was successfully calibrated with a concentration of 354 ug/L at VE532 (actual detected concentration of 340 ug/L) within the box culvert backfill. The modeled concentration rises at the estimated downgradient extent of the plume near MW509 (approximately 650 ug/L) then decreases to an estimated concentration of 8 ug/L, at the

terminus of the Duck Creek concrete conveyance system. The predicted 8 ug/l concentration is approaching the PRG for 1,4-dioxane in tap (drinking) water of 6.1 ug/L. Because the transport occurs within the utility backfill and not the box culvert itself, this groundwater would continue in a downgradient path under the concrete-lined ditch.

Confirmation groundwater grab samples were collected in October 2005 to verify these modeling results (CH2M HILL, 2005b). One sample was collected south of the Duck Creek box culvert at the same location and depth as the previous grab groundwater sample (location VE 535) and one sample was collected from the backfill of the Duck Creek box culvert at the downgradient terminus of the box culvert. Both groundwater samples were analyzed for VOCs and exhibited concentrations below laboratory method detection limits (MDLs), except for PCE in one sample which was above MDL's but below Ohio MCLs. Site COCs were therefore verified as not migrating past the Duck Creek box culvert above concentrations of concern. A summary of the confirmation sampling is presented in a technical memorandum included in Appendix C of this report.

During separate investigations, samples were collected from the only identified seep in the Duck Creek concrete conveyance system; no COCs were detected in the sample. As previously discussed, there were no detectable concentrations of any COCs in surface water samples collected from the effluent of the Duck Creek concrete conveyance system during the history of investigations performed (TPF, 2005).

Although the contaminants in groundwater are captured by backfill around subsurface drainage structures, it is not the actual structure itself (the 96-inch sewer pipe or the box culvert) that provides the capture. If the utilities themselves were ever removed, the backfill (if left in its present form) would still provide capture. Additionally, the natural flow direction was toward the ravines and Duck Creek prior to construction of the anthropogenic features (Section 4.1). Therefore, it is anticipated that flow components and plume stability would remain the same even if the trench backfill was also removed.

5.0 Risk Assessment

5.1 Human Health Risk Assessment

The final Human Health Risk Assessment (HHRA) Addendum (CH2M HILL, 2006) provided additional evaluation of potential risks to on- and off-site individuals who could potentially become exposed to contaminants in soil and groundwater detected at the Site. The results from the HHRA Addendum are appended to the Baseline Risk Assessment reported in the RI and address potential risks given reasonably foreseeable current and future land use assumptions. The numerical risk estimates were developed using conservative assumptions, which would tend to overstate rather than understate risks associated with the Site. The key conclusions from the HHRA Addendum are that risks to human health are at acceptable levels except as stated below:

- Potential indoor inhalation risks to on-site EMD workers from vapor intrusion are higher than USEPA risk reduction goals for corrective action. However, the potential exposures are based on overly conservative assumptions regarding contaminant distributions that may actually be encountered at the Site. In addition, the estimated inhalation exposures are far below occupational exposure limits for those same VOCs stored and handled at the facility. Potential exposures to VOCs overall at the facility are controlled through normal operating procedures, industrial hygiene practices, and engineering controls. The results of the HHRA Addendum indicate that potential vapor intrusion would not affect EMD's ability to manage overall exposures to VOCs.
- At limited locations, potential inhalation risks to on-site construction workers are higher than USEPA risk reduction goals. Most of the locations off-site where construction workers could encounter contaminants in soil or groundwater are unlikely to pose risks higher than risk reduction goals.

The final HHRA Addendum also identified a limited area off-site where construction worker risks slightly exceeded risk reduction goals. However, those calculations were based on two soil samples from 1997. Those two soil sample locations were re-sampled in May 2006 and the risk calculations were revised. The results were presented in a technical memorandum that was submitted as a revision to the HHRA Addendum for Off-Site Soils (CH2M HILL, 2006b) with this document. The technical memorandum stated that there are currently no unacceptable off-site human health risks above USEPA risk reduction goals.

5.2 Evaluation of Potential Ecological Exposure Pathways

The Site is located in an urban/industrial area which has been developed for several decades. It is bounded on the south and east by transportation corridors, on the west by an active industrial facility, and on the north by a local street and commercial and residential properties. The Site is largely covered with asphalt, gravel, buildings, or concrete. An ecological survey conducted as part of the RI (TPF, 1996) identified three grassy areas that

potentially represented ecological habitat. In addition, the Site is within the Duck Creek drainage area and both the East Ravine and West Ravine were part of the Duck Creek drainage.

The survey of these three areas indicated they were unlikely to support significant vegetation growth, and showed little evidence of wildlife species. The limited size of the habitat, and industrial nature of the surrounding area, indicated that few of the predominant species found in similar habitats in southwestern Ohio would be present at the site. The habitat is not of the types preferred by the two endangered species known to occur in Hamilton County (Bald Eagle and Sharp-shinned Hawk) and therefore those two species are unlikely to occur at the Site.

In general, the relative size of the Site was concluded to be too small to support a significant terrestrial population of any potential receptor species, and that animal and plant species diversity was low (TPF, 1996). Therefore, it is unlikely that significant ecological receptors would be present at the Site.

Potential ecological risks were quantified at on-site locations as part of the RI (TPF, 1996). A limited exposure assessment, considering soil ingestion by terrestrial mammals concluded that potential exposures were far lower than no observed adverse effects levels (NOAELs) for the chemicals of concern at the Site. Therefore, ecological risks were concluded not to be present from the SVOCs, PCBs, and metals in soil.

The potential occurrence of habitat and ecological receptors at off-site locations within the highway right-of-way is assumed to be similar to the grassy areas evaluated as ecological site characterization conducted during the RI. While terrestrial receptors may be present in these locations, contaminants generally are not detected in surface soil off-site, therefore the potential for terrestrial organisms at off-site locations to have contact with contaminants from the site is considered remote.

VOCs have not been detected in surface water in Duck Creek (TPF, 2005). The habitat of Duck Creek in the vicinity of EMD has been altered so there would be minimal impact to the aquatic ecosystem. Ohio EPA has assessed 3.9 miles of Duck Creek and determined an aquatic life use designation of Limited Resource water with essentially no restorability (Ohio Administrative Code Chapter 3745-1-07). Therefore, under the conditions expected to be present at Duck Creek, VOCs are not likely to pose a risk to aquatic receptors, if any are present.

Overall the potential for ecological risks at the Site, either at on-site or off-site locations is negligible. The presence of ecological receptors and supporting habitat is limited. Potential exposure pathways at off-site locations are incomplete.

6.0 References

Note: Not all references included herein were cited in this document. This list of references is intended as a guide for further project research.

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The Payne Firm, Inc. 1997b. Technical Memorandum No. 11 "Hot Spot Delineation and Removal Interim Action Report".

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The Payne Firm, Inc. 2000. Feasibility Study Report for the EM Science Site, Cincinnati, Ohio.

The Payne Firm, Inc. 2005. USEPA RCRA Voluntary Corrective Action Update to Post RI/FS Investigations (UPI Report). EM Science, Division of EM Industries, Inc.

USEPA and PRC Environmental Management, Inc., 1990. Preliminary Assessment/Visual Site Inspection. EM Science, Cincinnati, Ohio, Final Report.

USEPA, 2004. Voluntary Corrective Action Agreement, USEPA with EM Science, Chicago, Illinois.

Appendix A

Investigation Summary

Brief overview of work performed to date including investigations and documents prepared

Before the OEPA Administrative Order on Consent

- 1981 US EPA and OEPA analyzed leachate at mouth of West Ravine.
- 1983 Sump 562 constructed to capture leachate at mouth of West Ravine.
- 1985 EM Science submitted an initial "Draft RI/FS Work Plan" to OEPA. EM Science proceeded with voluntary RI sampling activities.
- 1986 Draft RI Report submitted to OEPA
- 1987 Storm Water Management Program initiated to control on-site storm water runoff and infiltration.
- 1987-1988 French Drain installed to capture impacted groundwater along eastern portion of property.
- 1988 Draft RI Report revised and re-submitted to OEPA
- 1990 Draft RI Report revised and re-submitted to OEPA
- 1990 Preliminary Assessment/Visual Site Inspection (PA/VSI) conducted by PRC Environmental Management, Inc.
- Reference:
 - Interim Action Efficacy Report, 1994;
 - Technical Memorandum "Current Status of Solid Waste Management Units and Areas of Concern", 2004.

OEPA Administrative Order on Consent Activities

- 1992 OEPA and EM Science sign Administrative Order on Consent (Order) to govern management and completion of future EM Science RI/FS activities.
- 1992 Well P6A installed to capture impacted groundwater flowing deeper than the capture zone of French Drain.
- 1993 Work Plan for the Remedial Investigation/Feasibility Study of the EM Science Site submitted to OEPA.
- 1996 Security fencing installed to prevent unauthorized access to the impacted areas at mouth of West Ravine
- 1996 EM Science Remedial Investigation Report submitted to OEPA.
- 1997 "Hot Spot" assessment and removal actions for mercury impacted soils. Potentially PCB impacted soils identified were later determined to not be present. VOC impacted soils identified in the subsurface near Building 4 to be addressed under human health risk assessment.
- 1997 TM-10 "RAO Technical Memorandum and Initial Technology Screening" submitted to OEPA.
- 1998 TM-14 "Alternatives Array Report" submitted to OEPA.
- 2000 EM Science Feasibility Study Report submitted to OEPA by The Payne Firm, Inc.
- 2001 Streamlined Feasibility Study for the EM Science Site entered into record by OEPA.
- 2002 Addendum to the Streamlined Feasibility Study for the EM Science Site entered into the record by OEPA.

- 2004 Feasibility Report for the EM Science Site entered into record by OEPA who wrote the document.
- 2004 Order between EMD and OEPA satisfied.
- References:
 - Administrative Order on Consent, 1992;
 - Work Plan for the Remedial Investigation/Feasibility Study of the EM Science Site, 1993;
 - Interim Action Efficacy Report, 1994;
 - Interim Action Work Plan (IAWP) – 1 “Temporary Fencing along ODOT Right-of-Way”, 1995;
 - EM Science Remedial Investigation Report, 1996;
 - TM-10 “RAO Technical Memorandum and Initial Technology Screening”, 1997;
 - TM-11 “Hot Spot Delineation and Removal Interim Action Report”, 1997;
 - TM-14 “Alternatives Array Report”, 1998;
 - Feasibility Study Report for the EM Science Site, 2000 (TPF);
 - Streamlined Feasibility Study for the EM Science Site, 2001 (OEPA);
 - Addendum to the Streamlined Feasibility Study for the EM Science Site, 2002 (OEPA);
 - Feasibility Study Report for the EM Science Site, 2004 (OEPA).

Voluntary Corrective Action Agreement Activities (as of June 2006)

- 2004 Voluntary Corrective Action Agreement (VCAA) between USEPA and EMD Chemicals Inc. signed.
- 2005 VCAA Update to Post RI/FS Investigations (UPI) for the EMD Chemicals Site submitted to USEPA.
- 2005 Human Health Risk Assessment Addendum for the EMD Chemicals Site submitted to USEPA. Adds to Baseline Risk Assessment in 1996 EM Science RI submittal.
- 2005 Confirmation Sample Collection for Completion of CA750 Groundwater EI is submitted to USEPA. Includes information regarding groundwater grab samples collected in October 2005.
- 2006 Human Health Risk Assessment Addendum (Revised) for EMD Chemicals Inc. site submitted in USEPA. Additional modifications to the Baseline Risk Assessment including off-site populations and indoor air vapor inhalation potential risks.
- Technical Memorandum to the 2006 Human Health Risk Assessment Addendum for Off-Site Soils for the EMD Chemicals site submitted to USEPA. Includes off-site risk re-calculations using new soil sampling data collected in May 2006.

Appendix B

Groundwater Plume Capture Modeling

Groundwater Plume Capture Modeling

Capture modeling was performed, using groundwater flow system volume estimates coupled with mass flux calculations for 1,4-dioxane and trichloroethene (TCE) as applicable, to determine the fate of constituents of concern (COCs) in groundwater migration from EMD Chemicals, Inc. Cincinnati, Ohio, property (Site) being intercepted primarily by the backfill of the 96-inch storm sewer, to a limited extent the sewer itself, and the backfill of the Duck Creek concrete conveyance (culvert) systems. The results of the modeling show that the groundwater concentrations migrating east and southeast from the Site are intercepted by the existing sewer and culvert backfills. As predicted by the model and confirmed with groundwater monitoring data, the concentrations of COCs are subsequently reduced primarily by dilution to:

- Non-detectable levels in the 96-inch storm sewer,
- A level that approaches the U.S.EPA Region 5 Preliminary Remediation Goal (PRG) for 1,4-dioxane in the backfill at the downgradient extent of the Duck Creek concrete conveyance (Figure 1-1).

The processes used to perform the modeling are presented below.

Groundwater Discharge Volume Calculation Procedure

Establish Flow Tubes

The process of using flow tubes is common when determining the fate of a water system along a given path. Flow tubes were used in this evaluation to establish the probable direction of groundwater flow and determine the horizontal areas of groundwater flow as groundwater discharges into the culvert and sewer backfill trenches. The segments of the backfill trenches that are receiving groundwater from individual flow tubes are shown on Figure 1-1. Flow tubes were identified for three sections of the Duck Creek box culvert backfill and two sections of the 96-inch storm sewer backfill:

- Duck Creek west half of plume: west of VE532 (temporary well in the backfill)
- Duck Creek east half of plume: from VE532 to east edge of plume
- Duck Creek downgradient of plume: from east edge of plume to Duck Creek Outflow
- 96-inch plume section: north edge of plume to Sewer C
- 96-inch downgradient of plume: from Sewer C to MW506

In addition to the flow tubes, the flows in the backfill trenches themselves were represented. The widths of the tubes and trenches, as well as the other model parameters, are presented in Table B-1.

Groundwater Gradients

Groundwater gradients were calculated in each flow tube and backfill trench from groundwater elevations in monitoring wells within and adjacent to the backfill trenches:

- For the north side (where 1,4-dioxane has been observed in groundwater) of the Duck Creek box culvert, the groundwater gradient within the Fill unit was

calculated between MW508 and MW510A and the groundwater gradient within the Lower Clay unit was calculated between MW508B and MW510B.

- For the south side of the Duck Creek box culvert, the groundwater gradients within the Fill and Lower Clay units were estimated as twice those of the plume side, based on the projected groundwater elevation measured from VE534.
- For the gradient within the Duck Creek box culvert backfill, the elevation gradient of the culvert inverts was used.
- For the west or “plume” side of the 96-inch sewer, the groundwater gradient within the Fill unit was calculated between MW016 and MW023 and the groundwater gradient within the Lower Clay unit was calculated between MW031D and P09. The Fill unit gradient in the flow tube downgradient of the plume used historical groundwater elevations from MW020 (abandoned) but was divided by five to account for the very low estimated infiltration in this area between the plumes. The low infiltration rate is due to the predominance of low-permeability units and the flow cut-off from the railroad fill (Section 4.2.2).
- For the east side of the 96-inch sewer, the groundwater gradients within the Fill and Lower Clay units were estimated as equal to those of the west side, based on the projected groundwater elevation measured from MW041. The Fill unit gradient in the flow tube downgradient of the plume used historical groundwater elevations from MW020 (abandoned) but was divided by five to account for the very low estimated infiltration in this area between the plumes.
- For the gradient within the 96-inch sewer backfill, the elevation gradient of the sewer inverts was used.

Saturated Thickness

Groundwater discharge occurs through the saturated interval defined horizontally by the flow tube width and vertically by the saturated unconsolidated thickness within the flow tubes (perpendicular to the direction of groundwater flow). Table B-1 presents the saturated thicknesses measured from wells within the Fill and Lower Clay units and the backfill trenches for each flow tube. Figure 4-2 shows the conceptual saturated thickness of discharge into the 96-inch storm sewer backfill, and Figure 4-4 shows the conceptual saturated thickness of discharge into the Duck Creek box culvert backfill.

Hydraulic Conductivity

Hydraulic conductivities were determined from slug test data from the nearest wells:

- For both the north and south sides of the Duck Creek box culvert, the hydraulic conductivity within the Fill unit was calculated from the slug test at MW510A and the hydraulic conductivity within the Lower Clay unit was calculated from the slug test at MW510B.
- For the hydraulic conductivity within the Duck Creek box culvert backfill, the slug test data from Site wells screened in sand similar to the backfill sand was used, based on examination of similar geologic descriptions in boring logs.
- For the west and east sides of the 96-inch sewer, the hydraulic conductivity within the Fill unit was calculated from the average of slug tests from Site wells screened

within clayey sand and the hydraulic conductivity within the Lower Clay unit was calculated from the slug test at MW030.

- The hydraulic conductivity within the 96-inch sewer backfill was estimated during calibration to concentrations at the Sewer C seep location approximately 25 feet south of MW023. This value approximates the hydraulic conductivity that would be expected from mixed sand/clay backfill.

Groundwater Discharge Volume Calculation

The calculated groundwater discharge is the groundwater flow rate through the vertical saturated unconsolidated area along a determined width of saturated area. The above data are put into the Darcy's Law formula for each inflow face (Fill, Lower Clay and backfill) for each flow tube section, and the results are presented in Table B-1:

$$Q=k*A*i$$

Where

- Q = discharge (groundwater volume/time)
- k = hydraulic conductivity (distance/time)
- A = area through which the groundwater flows (distance*distance)
- i = groundwater gradient magnitude through the area of flow (dimensionless, or distance/distance)

With all inputs to the equation being in units of feet and days, the resulting discharge volume in cubic feet is converted to gallons by multiplication of a unit conversion factor of 7.48. The discharge values in Table B-1 are reported in gallons per day.

Mass Flux Calculation Procedure

For each inflow face of each flow tube section, the representative COC concentration was multiplied by the inflow face's calculated groundwater flow volume (and a unit conversion factor of 3.79 to convert from gallons to liters).

Migration Towards the East to the 96-inch storm sewer backfill

TCE and 1,4-dioxane were the most prominent COCs observed in groundwater collected from:

- monitor wells completed near or within the backfill of the sewer; and,
- the Sewer C seep.

Therefore these COCs were selected for modeling to determine the fate of all intercepted COCs. The volume of groundwater discharged to the backfill from the west side (COC influx), the east side, and flow through the backfill from upgradient of the site (clean water influx) were used to estimate concentration changes due to dilution. Model calibration was performed using the concentrations detected in groundwater samples collected from MW-23, MW-18 and MW-506.

The model predicted that the concentrations of 1,4-dioxane would be below method detectable levels at MW-506, but that concentration of TCE would be 7 ug/L, above the

reporting limit. COCs have not been detected in groundwater samples collected from MW-506 during subsurface investigations performed at the site, thus confirming the model results for 1,4-dioxane. In the case of TCE and other chlorinated COCs, the concentrations are also reduced by volatilization and possibly other natural attenuation processes (in addition to the dilution predicted by this model), as evidenced by the non-detection of TCE in the sample actually collected from MW506. This calibration technique was then applied to determine the fate of 1,4-dioxane in the southeast plume at the Duck Creek box culvert conveyance.

Migration Towards the Southeast to Duck Creek box culvert backfill

1,4-dioxane was the most prominent COC observed in groundwater collected from monitor wells completed near or within the backfill of the culvert system and therefore was selected for modeling to determine the fate of all intercepted COCs. Therefore, only 1,4-dioxane concentrations were modeled.

The model was successfully calibrated with a modeled concentration of 354 ug/L at VE532 (actual detected concentration of 340 ug/L) within the box culvert backfill. The modeled concentration increases at the estimated downgradient extent of the plume near MW509 (approximately 650 ug/L) then decreases to an estimated concentration of 8 ug/L, at the terminus of the Duck Creek concrete conveyance system. The predicted 8 ug/L concentration is approaching the Preliminary Remediation Goal for 1,4-dioxane of 6.1 ug/L. Because the transport occurs within the utility backfill and not the box culvert itself, this groundwater would likely continue in a downgradient path under the concrete-lined ditch where the effects of dilution and dispersion would likely decrease 1,4-Dioxane to below PRGs.

Table B-1

Summary of Groundwater Plume Capture Calculations

Appendix B, Conceptual Model of Current Conditions

EMD Chemicals, Inc, Cincinnati, Ohio

	Flow Tubes				
	East Plume into 96-inch Storm Sewer Backfill		Southeast Plume into Duck Creek Box Culvert Backfill		
	Plume Width	Downgradient of Plume to MW506	West Half of Plume	East Half of Plume	Downgradient of Plume to DC Outflow
Plume Side INFLOW					
Fill Unit					
K (hydraulic conductivity, ft/d)	2.10E-02	2.10E-02	2.10E-01	2.10E-01	2.10E-01
A (area, ft ²)	2160	1980	375	450	862.5
width (ft)	240	180	250	300	575
saturated thickness (ft)	9	11	1.5	1.5	1.5
i (gradient, ft/ft)	0.0008	0.0008	0.0215	0.0215	0.0215
Q (discharge volume, gal/d)	0.27	0.25	12.68	15.21	29.16
1,4-dioxane concentration (ug/L)	390	0	1100	1900	0
TCE concentration (ug/L)	210	0	0	0	0
Lower Clay Unit					
K (hydraulic conductivity, ft/d)	5.67E-02	5.67E-03	2.83E-05	2.83E-05	2.83E-05
A (area, ft ²)	720	540	2250	2100	4025
width (ft)	240	180	250	300	575
saturated thickness (ft)	3	3	9	7	7
i (gradient, ft/ft)	0.0352	0.0352	0.0554	0.0554	0.0554
Q (discharge volume, gal/d)	10.75	0.81	0.03	0.02	0.05
1,4-dioxane concentration (ug/L)	390	0	380	380	0
TCE concentration (ug/L)	210	0	0	0	0
Backfill INFLOW					
K (hydraulic conductivity, ft/d)	5.67E-02	2.83E-02	2.83E-01	2.83E-01	2.83E-01
A (area, ft ²)	60.6	60.6	166.32	166.32	166.32
width (ft)	30	30	56	56	56
saturated thickness (ft)	2.02	2.02	2.97	2.97	2.97
i (gradient, ft/ft)	0.0238	0.0238	0.0031	0.0031	0.0031
Q (discharge volume, gal/d)	0.61	0.31	1.08	1.08	1.08
1,4-dioxane concentration (ug/L)	0	190	0	340	626
TCE concentration (ug/L)	0	160	0	0	0
Opposite Side INFLOW					
Fill Unit					
K (hydraulic conductivity, ft/d)	2.10E-02	2.10E-02	2.10E-01	2.10E-01	2.10E-01
A (area, ft ²)	2160	1980	375	450	862.5
width (ft)	240	180	250	300	575
saturated thickness (ft)	9	11	1.5	1.5	1.5
i (gradient, ft/ft)	0.0008	0.0040	0.0431	0.0431	0.0431
Q (discharge volume, gal/d)	0.27	1.24	25.35	30.42	58.31
1,4-dioxane concentration (ug/L)	0	0	0	0	0
TCE concentration (ug/L)	0	0	0	0	0
Lower Clay Unit					
K (hydraulic conductivity, ft/d)	5.67E-02	5.67E-03	2.83E-05	2.83E-05	2.83E-05
A (area, ft ²)	720	540	2250	2100	4025
width (ft)	240	180	250	300	575
saturated thickness (ft)	3	3	9	7	7
i (gradient, ft/ft)	0.0008	0.1760	0.1107	0.1107	0.1107
Q (discharge volume, gal/d)	0.27	4.03	0.05	0.05	0.09
1,4-dioxane concentration (ug/L)	0	0	0	0	0
TCE concentration (ug/L)	0	0	0	0	0
Flow Tube OUTFLOW					
Summed TCE Volumetric Concentration (ug/L)	102	7	--	--	--
Summed 1,4-dioxane Volumetric Concentration (ug/L)	190	9	356	626	8
Target Concentration (ug/L)	--	ND (TCE and 1,4-dioxane)	340 (1,4-dioxane)	--	--

Notes:

ft = feet

d = day

gal = gallons

ug = micrograms

L = liter

ND = not detected = less than reporting limit

1,4-dioxane: reporting limit = 50 ug/L; method detection limit = 12 ug/L

TCE (trichloroethene): reporting limit = 1 ug/L; method detection limit < 0.5 ug/L

Other factors besides dilution, which is the only factor modeled here, reduce the concentration of TCE: natural attenuation, dispersion, etc.

Appendix C
Confirmation Sample Collection Tech Memo



CH2MHILL

CH2M HILL
One Dayton Centre
Suite 1100
One South Main Street
Dayton, OH 45402
Tel 937.228.3180
Fax 937.228.7572

December 16, 2005

Mr. Donald Heller
USEPA Region 5
DW-8J
77 West Jackson Blvd.
Chicago, IL 60604-3507

**Subject: Confirmation Sample Collection for Completion of CA750 Groundwater
Environmental Indicators - EMD Chemicals Inc. Voluntary Corrective Action
Agreement Submittal.**

Dear Don:

On behalf of EMD Chemicals Inc. (EMD), CH2M HILL is submitting the attached document which presents the results of confirmation grab groundwater sampling performed per the request of USEPA, Region 5 to verify migration of contaminated groundwater is under control.

Per our discussions, this submittal will provide the USEPA, Region 5 with the final information necessary to complete the Environmental Indicators CA 750 document with a RCRIS status code of "YE", migration of contaminated groundwater is under control at the site.

Please call me at (937) 228-3180 ext. 233 if you have any further questions.

Sincerely,

CH2M HILL

Mark Altic
Project Manager

CC: Paul Nelson - EMD Chemicals Inc.
Joe Smindak - Ohio EPA, SWDO
Public Repository (via TPF) - Cincinnati Public Library, Norwood Branch
Dan Weed - TPF

Confirmation Sample Collection for Completion of CA750 Groundwater Environmental Indicators – EMD Chemicals Inc. Voluntary Corrective Action Agreement Submittal

PREPARED FOR: Mr. Don Heller (USEPA, Region 5 Project Manager)

PREPARED BY: Mark Altic (CH2M HILL)
Angela Hurley (The Payne Firm)

COPIES: Mr. Joe Smindak (Ohio EPA)
Mr. Paul Nelson (EMD)
Mr. Mike Mulligan (EMD)
Mr. Dan Weed (The Payne Firm)

DATE: December 16, 2005

Introduction

EMD Chemicals Inc. (EMD) is currently pursuing corrective actions under a Voluntary Corrective Action Agreement (VCAA) between EMD, located at 2909 Highland Avenue, Cincinnati, Ohio (Facility), and the United States Environmental Protection Agency (US EPA). Section V.C.1 of the VCAA stipulates that by March 2005, EMD will submit an Environmental Indicators Report, including a draft CA750 reporting form, and perform any other necessary activities sufficient to permit U.S. EPA to determine that migration of contaminated groundwater at or from the Facility is controlled. On March 30, 2005, EMD submitted a draft of the CA750 form and a document entitled Conceptual Model of Current Conditions (CMCC) (CH2M HILL, 2005) which presented all available information into a high-level understanding of the Site's historical operations (including SWMUs/AOCs), hydrogeology, distribution, fate, and transportation of constituents of concern (COCs) in soil and groundwater. The CMCC referenced all historical investigations and information obtained during Remedial Investigations/Feasibility Studies performed under the Administrative Order On Consent and the VCAA.

The CMCC included a demonstration that the migration of contaminated groundwater was under control via a simplistic groundwater model, calibrated with site specific groundwater data (potentiometric surface, concentrations of COCs in groundwater as detected in samples obtained from monitor wells, etc.). This model predicted that COCs would not be present on the south side of the Duck Creek Box Culvert and that the maximum observed concentration of 1,4-dioxane that would be observed at the terminus of the Duck Creek Box Culvert would be approximately 8 ug/l (see Figure 1-1 from the CMCC, attached).

Via e-mail communication on September 26th, Mr. Don Heller, USEPA, Region 5 Site Coordinator, indicated that based upon the model presented/referenced in the CMCC/draft CA750 submittals, the migration of contaminated groundwater appeared to be under control from the facility. However, Mr. Heller requested verification of the model with the collection of two more grab groundwater samples from two specific locations:

- Location 1 – at the former temporary monitor well location VE-535 (south side of the Duck Creek Box Culvert) from the same interval as the previous grab sample was collected; and,
- Location 2 - from the backfill of the Duck Creek Box Culvert at its terminus.

EMD agreed to this request and submitted a notice of fieldwork and a plan for sample collection via e-mail on September 28th. The purpose of this document is to present the findings of the additional grab groundwater sample collection event requested by US EPA and to serve as a supplement to both the CMCC and the draft CA750 March 2005 submittals.

Supplemental Data Collection – Grab Groundwater Samples

Two additional direct-push borings converted to temporary monitoring wells were installed on October 10, 2005 by EnviroCore Drilling coordinated by EMD's consultant, The Payne Firm to obtain the additional water samples requested by USEPA. Work was performed within portions of the ODOT Right-of-Way along Interstate 71. An existing ODOT permit was extended to complete the work. Sample collection, quality assurance/quality control procedures, employment of data quality objectives, and containment of drilling waste was coordinated by a Payne Firm geologist in accordance with the Payne Firm's SOPs and project-specific Quality Assurance Project Plan (QAPP).

Grab groundwater samples were collected at two locations shown on Figure 1, VE535 (Location 1) and VE543 (Location 2). A Geoprobe[®] rig was used to complete these borings into the units of interest and to install 1-inch temporary monitoring wells. Lithology was logged by a Payne Firm geologist. Boring logs are included as Attachment 1. A primary boring was advanced at each location into the unsaturated portion of the Norwood Trough aquifer to confirm the lithology previously identified during past investigations and to confirm the absence of groundwater in the upper portion of the Norwood Trough Aquifer unit. Once lithology was verified, a second boring was drilled immediately adjacent to the first boring to facilitate temporary monitor well installation.

At the previous VE535 location, one ground water grab sample was collected from the temporary monitor well screened approximately 12-17 feet below ground surface, which is stratigraphically equivalent with the base of the Duck Creek Box Culvert backfill and is the same screened interval as the initial temporary groundwater monitor well. The other ground water grab sample was collected from the new VE543 location near the terminus of the Duck Creek Box Culvert. The water sample collected at the VE543 location was from the base of the saturated backfill of the Duck Creek Box Culvert, screened approximately 14-19 feet below ground surface. Both ground water samples were analyzed for volatile organic compounds (VOCs) by US EPA Method SW-846 8260B (Appendix IX list plus total 1,2-dichloroethene, cis-1,2-dichloroethene, and trans-1,2-dichloroethene) in accordance with the project QAPP. A licensed surveyor located the coordinates and elevations of the temporary monitoring well locations. Validated analytical laboratory data are provided in Table 1; the complete laboratory report is included on an attached CD.

Laboratory Results

With the exception of tetrachloroethene (PCE), no COCs were detected above laboratory reporting levels in the grab groundwater samples collected from either of the temporary groundwater monitor wells. These detected results are shown on Figure 1. All VOCs analyzed and results are included in Table 1.

Location 1 - VE535

No compounds were detected above the laboratory reporting limit in the grab groundwater sample collected from VE535. Estimated results were reported for cis-1,2-DCE at 0.67 J ug/l, as compared to 0.68 J ug/l detected in the grab groundwater sample collected from this location in August 2004.

Location 2 - VE543

PCE was detected in the groundwater sample collected from temporary groundwater monitor well VE543 (Duck Creek Box Culvert backfill material), at a concentration of 1.2 micrograms per liter (ug/l). This concentration is below the Ohio maximum contaminant level (MCL) for PCE of 5 ug/l. From the analyses performed on the VE543 grab groundwater samples, other compounds were reported as estimated by the laboratory including 1,2-Dichloroethane (1,2-DCA) at 0.20 J ug/l and cis-1,2-DCE at 0.25 J ug/l.

Conclusions

The following conclusions resulted from this event:

- The current analytical data at VE535 confirmed the data collected in August 2004 where no constituents were detected above the reporting limit, thus verifying that COCs are not migrating past the Duck Creek Box Culvert but are intercepted by the backfill of this structure.
- The concentrations of COCs in groundwater intercepted by the backfill surrounding the Duck Creek Box Culvert upgradient of the terminus of the structure are naturally attenuated to levels below laboratory method detection limits or MCLs by the time the groundwater flow through the structure's backfill reaches its terminus.

Both conclusions verify the prediction of the groundwater model presented in the CMCC. The model predicted that the concentration of 1,4-dioxane in the groundwater flowing from the backfill of the Duck Creek Box Culvert at its terminus would be approximately 8 ug/l (near the U.S.EPA, Region 9 preliminary remediation goal for 1,4-dioxane of 6.1 ug/l) and would not be present on the south side of the Duck Creek Box Culvert. 1,4-dioxane was not detected in either of the two confirmatory grab groundwater samples. The model also predicted that other COCs would be below MCLs for both locations. This has also been confirmed as a result of the grab groundwater sampling performed at both locations.



The Payne Firm, Inc.

EMD Chemicals Inc.

Norwood, Ohio

USEPA ID # OHD086438538

Project No. 0100.58.16

TABLE 1: Ground Water VOC Results at Direct-Push Ground Water Sampling Locations

ANALYTE	VE535 / 12-17 GW 2004-08-13 GWSC A4H140136003 µg/L	VE535 / 12-17 GW 2005-10-11 GWSC A5J120193002 µg/L	VE543 / 14-19 GW 2005-10-11 GWSC A5J120193001 µg/L
1,1,1,2-TETRACHLOROETHANE	< 1	< 1	< 1
1,1,1-TRICHLOROETHANE	< 1	< 1	< 1
1,1,2,2-TETRACHLOROETHANE	< 1	< 1	< 1
1,1,2-TRICHLOROETHANE	< 1	< 1	< 1
1,1-DICHLOROETHANE	< 1	< 1	0.54 J
1,1-DICHLOROETHENE	< 1	< 1	< 1
1,2,3-TRICHLOROPROPANE	< 1	< 1	< 1
1,2-DIBROMO-3-CHLOROPROPANE (DBCP)	< 2	< 2	< 2
1,2-DIBROMOETHANE	< 1	< 1	< 1
1,2-DICHLOROETHANE	< 1	< 1	0.2 J
1,2-DICHLOROETHENE (TOTAL)	0.68 J	0.67 J	< 2
1,2-DICHLOROPROPANE	< 1	< 1	< 1
1,4-DIOXANE	< 50	< 50	< 50
2-BUTANONE	< 10	6.1 J	0.6 J
2-HEXANONE	< 10	< 10	< 10
3-CHLOROPROPENE	< 2	< 2	< 2
4-METHYL-2-PENTANONE	< 10	0.65 J	< 10
ACETONE	1.5 J B	33 B	2.6 J B
ACETONITRILE	< 20	< 20	< 20
ACROLEIN	< 20	< 20	< 20
ACRYLONITRILE	< 20	< 20	< 20
BENZENE	< 1	< 1	< 1
BROMODICHLOROMETHANE	< 1	< 1	< 1
BROMOFORM	< 1	< 1	< 1
BROMOMETHANE	< 1	< 1	< 1
CARBON DISULFIDE	< 1	0.53 J	< 1
CARBON TETRACHLORIDE	< 1	< 1	< 1
CHLOROBENZENE	< 1	< 1	< 1
CHLOROETHANE	< 1	< 1	< 1
CHLOROFORM	< 1	< 1	< 1
CHLOROMETHANE	< 1	< 1	< 1
CHLOROPRENE	< 2	< 2	< 2
CIS-1,2-DICHLOROETHENE	0.68 J	0.67 J	0.25 J
CIS-1,3-DICHLOROPROPENE	< 1	< 1	< 1
DIBROMOCHLOROMETHANE	< 1	< 1	< 1
DIBROMOMETHANE	< 1	< 1	< 1
DICHLOROFLUOROMETHANE	< 2	< 2	< 2

B = Sample contained concentrations of target analyte(s) at a reportable limit in the associated Method Blank(s). (Qualified by STL, Inc.)

J = Estimated result; result concentration is below the laboratory's reporting limit (Qualified by STL, Inc.)

VOCs = Volatile Organic Compounds

ug/L = Micrograms Per Liter

DRAFT



The Payne Firm, Inc.

EMD Chemicals Inc.

Norwood, Ohio

USEPA ID # OHD086438538

Project No. 0100.58.16

TABLE 1: Ground Water VOC Results at Direct-Push Ground Water Sampling Locations

ANALYTE	VE535 / 12-17 GW 2004-08-13 GWSC A4H140136003 µg/L	VE535 / 12-17 GW 2005-10-11 GWSC A5J120193002 µg/L	VE543 / 14-19 GW 2005-10-11 GWSC A5J120193001 µg/L
ETHYL METHACRYLATE	< 1	< 1	< 1
ETHYLBENZENE	< 1	< 1	< 1
IODOMETHANE	< 1	< 1	< 1
ISOBUTANOL	< 50	< 50	< 50
METHACRYLONITRILE	< 2	< 2	< 2
METHYL METHACRYLATE	< 2	< 2	< 2
METHYLENE CHLORIDE	< 1	< 1	< 1
PROPIONITRILE	< 4	< 4	< 4
STYRENE	< 1	< 1	< 1
TETRACHLOROETHENE	< 1	< 1	1.2
TOLUENE	< 1	0.28 J	0.24 J
TRANS-1,2-DICHLOROETHENE	< 1	< 1	< 1
TRANS-1,3-DICHLOROPROPENE	< 1	< 1	< 1
TRANS-1,4-DICHLORO-2-BUTENE	< 1	< 1	< 1
TRICHLOROETHENE	< 1	< 1	< 1
TRICHLOROFLUOROMETHANE	< 1	< 1	< 1
VINYL ACETATE	< 2	< 2	< 2
VINYL CHLORIDE	< 1	< 1	< 1
XYLENES (TOTAL)	< 2	< 2	< 2

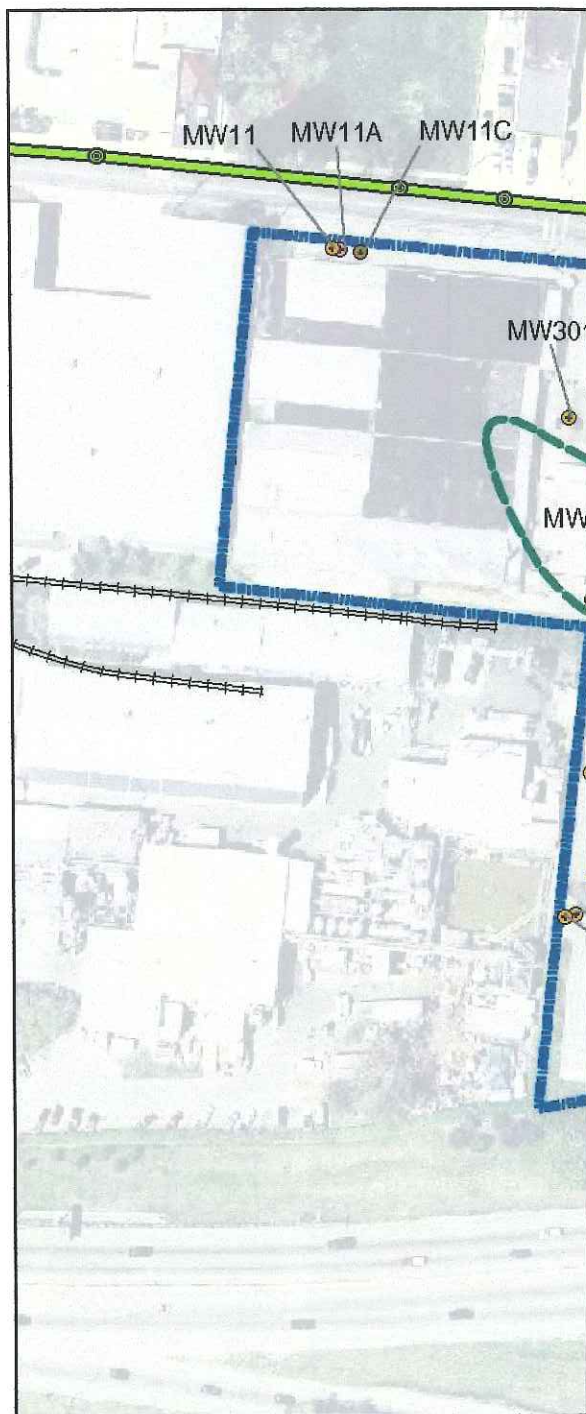
B = Sample contained concentrations of target analyte(s) at a reportable limit in the associated Method Blank(s). (Qualified by STL, Inc.)

J = Estimated result; result concentration is below the laboratory's reporting limit (Qualified by STL, Inc.)

VOCs = Volatile Organic Compounds

µg/L = Micrograms Per Liter

DRAFT

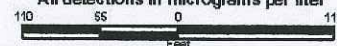


LEGEND

DRAFT

- ⊕ Well Screened in Upper Portion of Unit
- ⊕ Well Screened in Middle Portion of Unit
- ⊕ Well Screened in Lower Portion of Unit
- Sewer Backfill Monitoring Well
- Fill (B0) Monitoring Well
- Upper Till Sand Seams (C1) Monitoring Well
- Upper Sand Unit (D1) Monitoring Well
- Lacustrine Unit (D2) Monitoring Well
- Lower Clay Unit (D3) Monitoring Well
- Lacustrine-2 (D5) Monitoring Well
- ★ Storm Sewer Seep Sampling Location/
Surface Water Sampling Location
- New Direct-Push Ground Water Sampling Location
- 1" Temporary Monitoring Well (Fill-B0)
- 1" Temporary Monitoring Well (Lacustrine Unit-D2)
- Direct-Push Ground Water Sampling Location
- EMD Property Boundary
- ▨ Duck Creek Box Culvert Location
- Storm Sewer Locations
- Sanitary Sewer Locations
- ⊙ Sanitary Sewer Manhole
- Outline of Former West Ravine
- French Drain
- 36" Pipe (Removed)

PCE=Tetrachloroethene
1,2-DCA=1,2-Dichloroethane
cis-1,2-DCE=cis-1,2-Dichloroethene
All detections in micrograms per liter



10/11/05
PCE 1.2
1,2-DCA 0.20 J
cis-1,2-DCE 0.25 J

VE543/14-19

DC Outflow

8/13/04
cis-1,2-DCE 0.68 J
10/11/05
cis-1,2-DCE 0.67 J

VE535/12-17

TITLE

NEW DIRECT-PUSH GROUND WATER SAMPLING LOCATIONS (OCTOBER 2005)

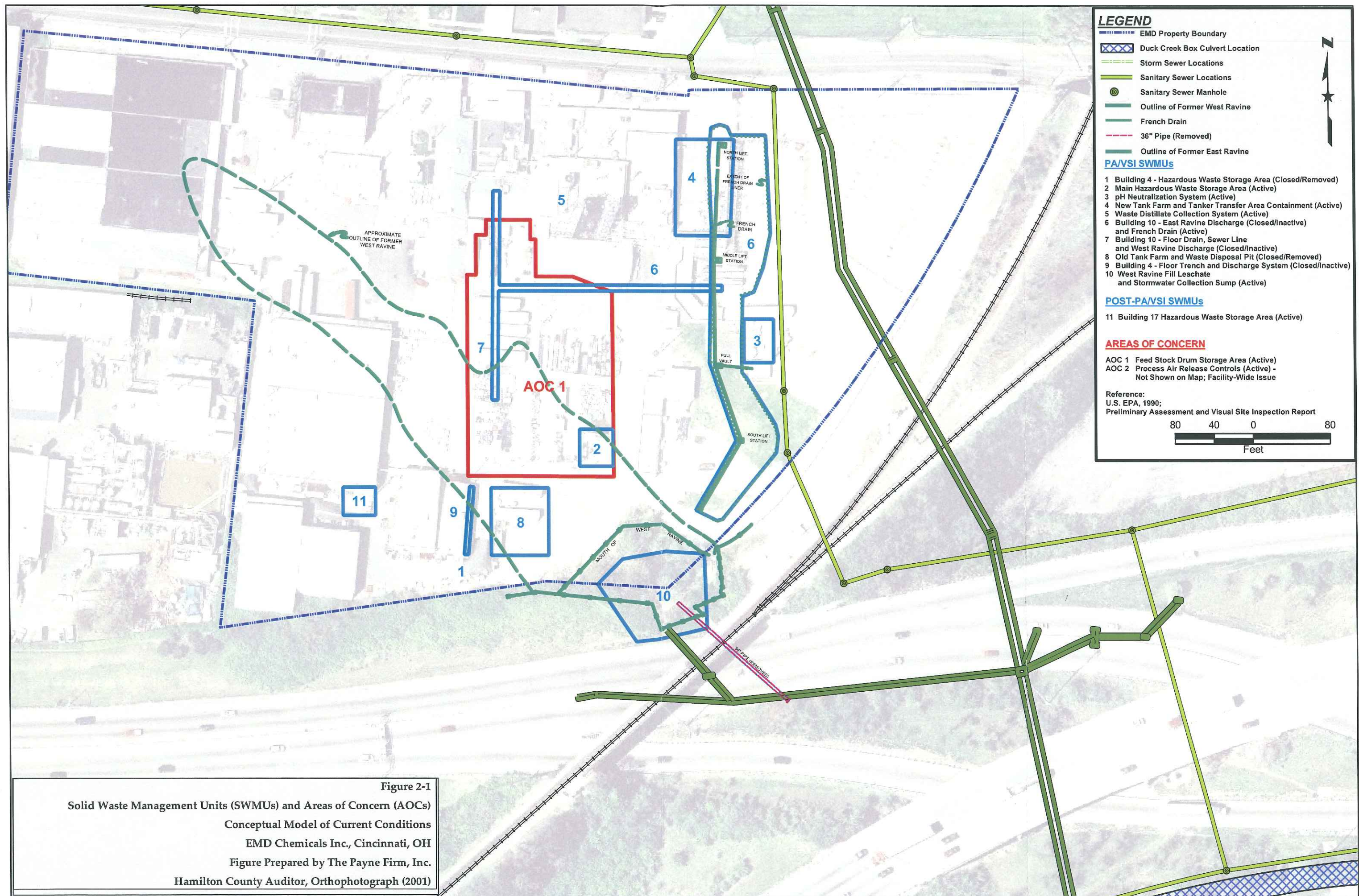
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DRAWN BY	ALH	APPROVED BY	KDK
CLIENT	EMD CHEMICALS INC.		
PROJECT NO.	100.58.16		

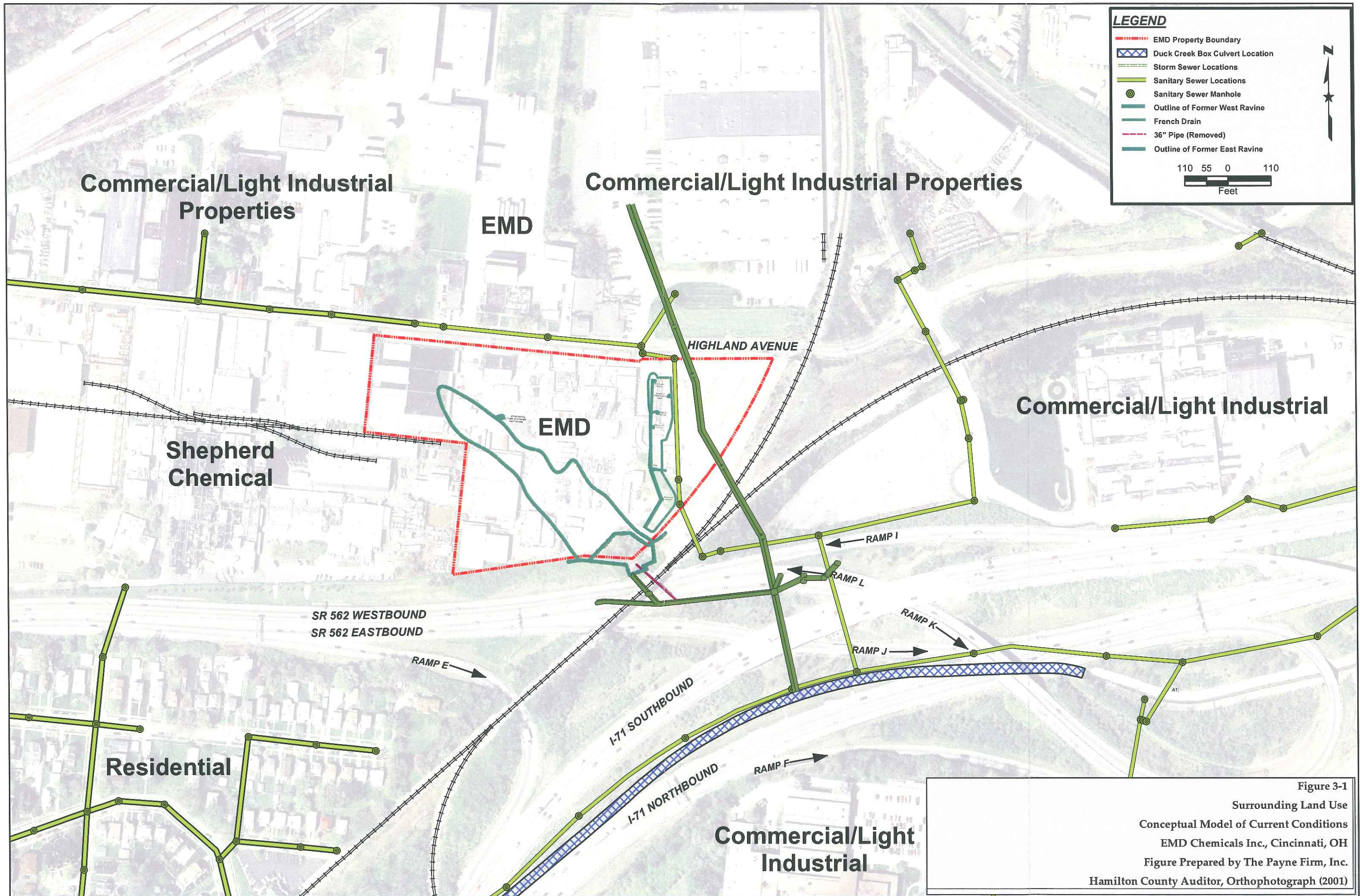


The Payne Firm, Inc.
Environmental Consultants
Cincinnati / Cleveland

REFERENCE Hamilton County Auditors, Orthophotograph (2001)

Figures





LEGEND

- Inactive Well
- Active Non-Potable, Industrial Process Well
- EMD Property Boundary

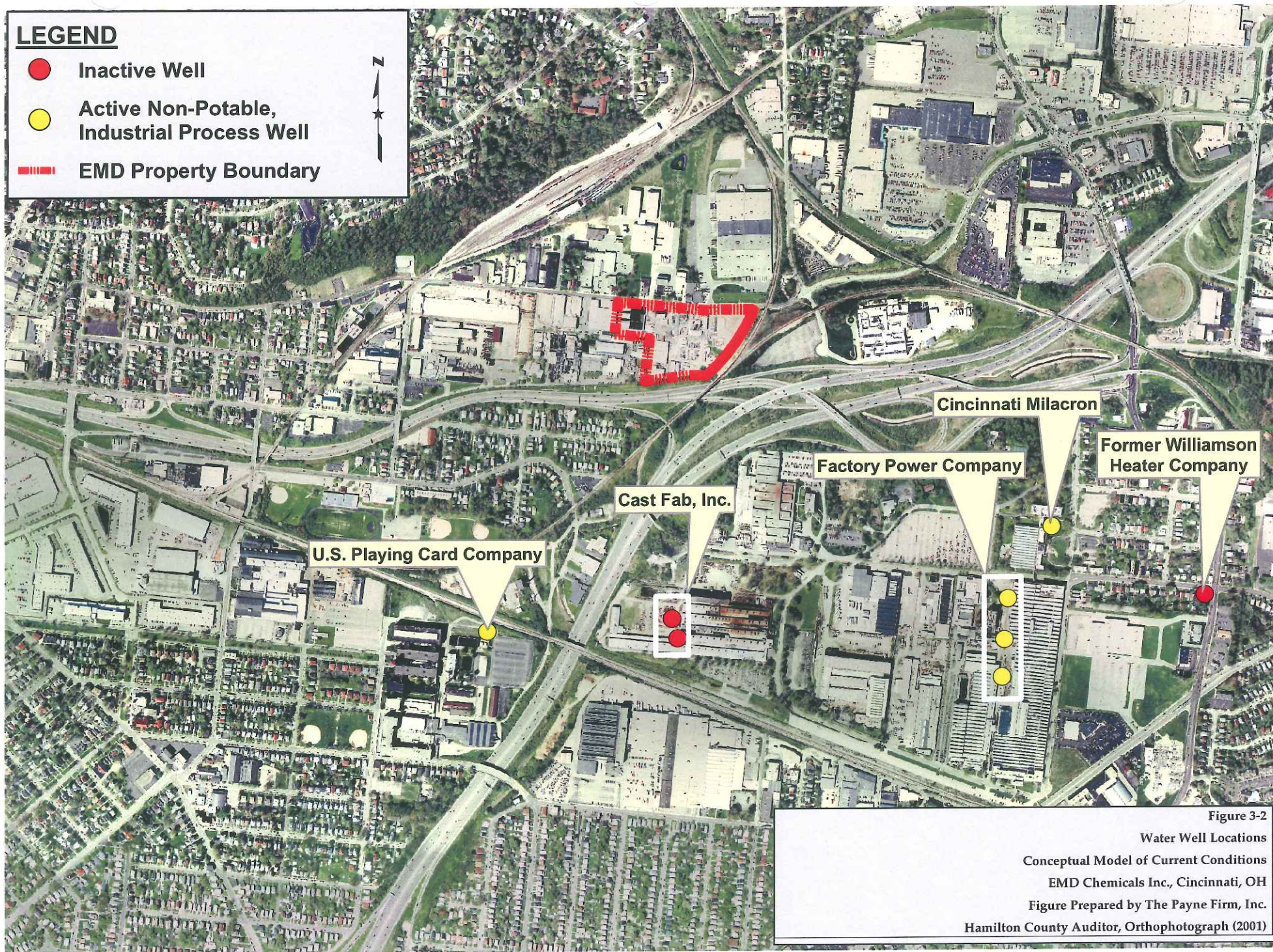
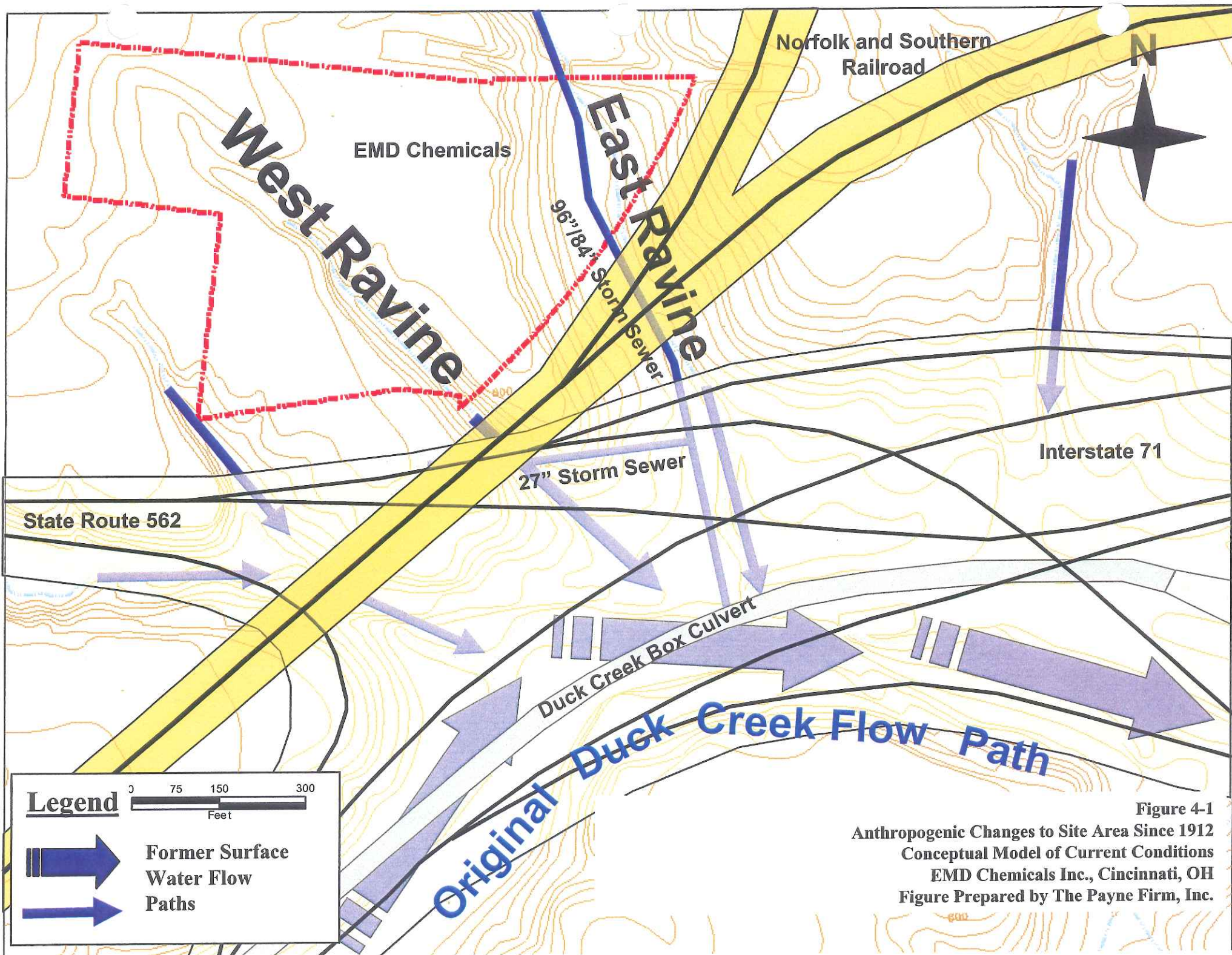
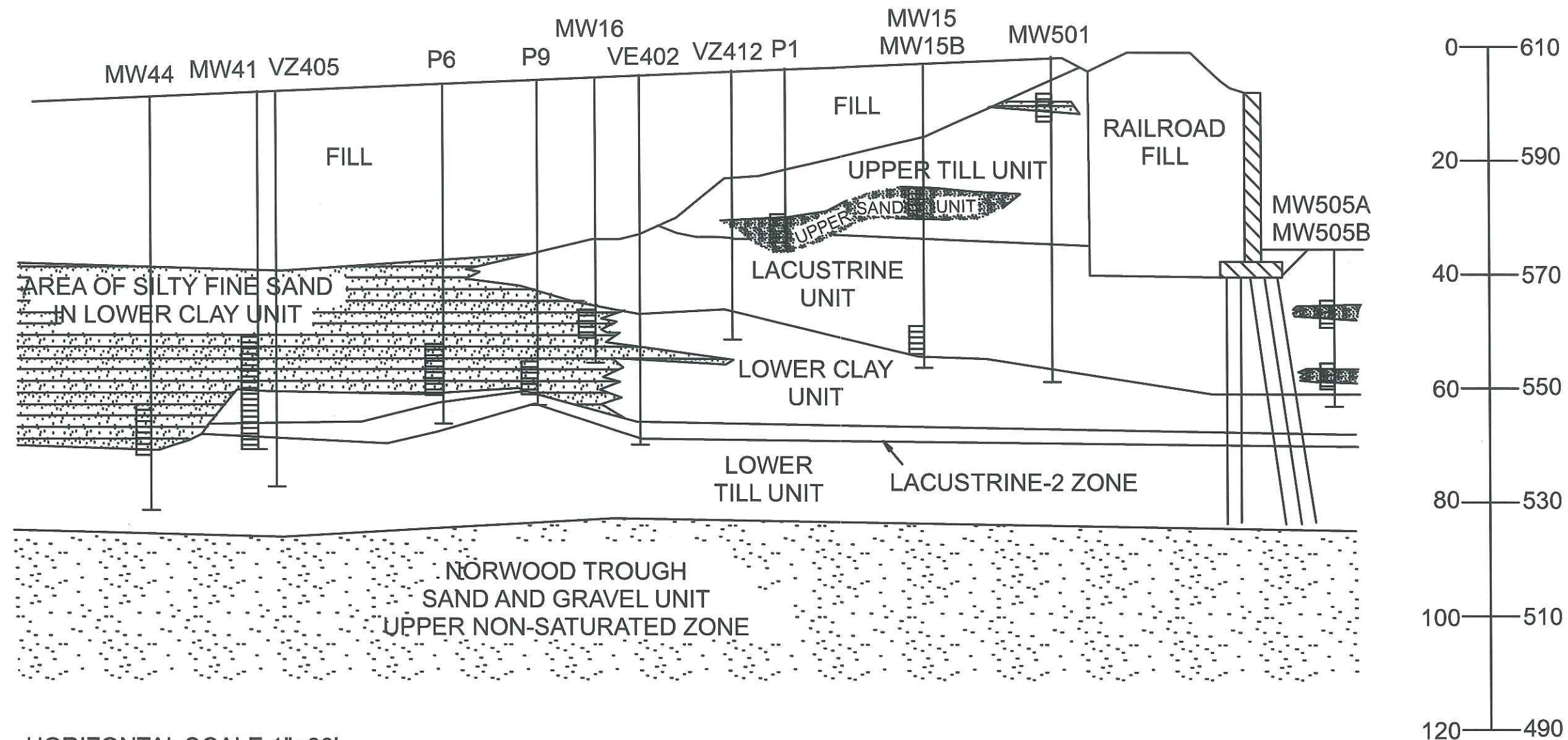


Figure 3-2
Water Well Locations
Conceptual Model of Current Conditions
EMD Chemicals Inc., Cincinnati, OH
Figure Prepared by The Payne Firm, Inc.
Hamilton County Auditor, Orthophotograph (2001)

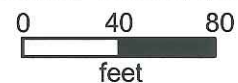


NORTH

SOUTH



HORIZONTAL SCALE 1"=80'



VERTICAL SCALE 1"=24'

LEGEND



SATURATED SAND SEAM OR LENS
IN THE PERCHED GROUND WATER SYSTEM



UNSATURATED, PARTIALLY CEMENTED
SILT, SAND, AND GRAVEL IN THE
CONFINING SYSTEM



AREAS OF COARSER GRAINED, UNSATURATED TO
SATURATED DEPOSITS IN THE LACUSTRINE AND
LOWER CLAY UNITS

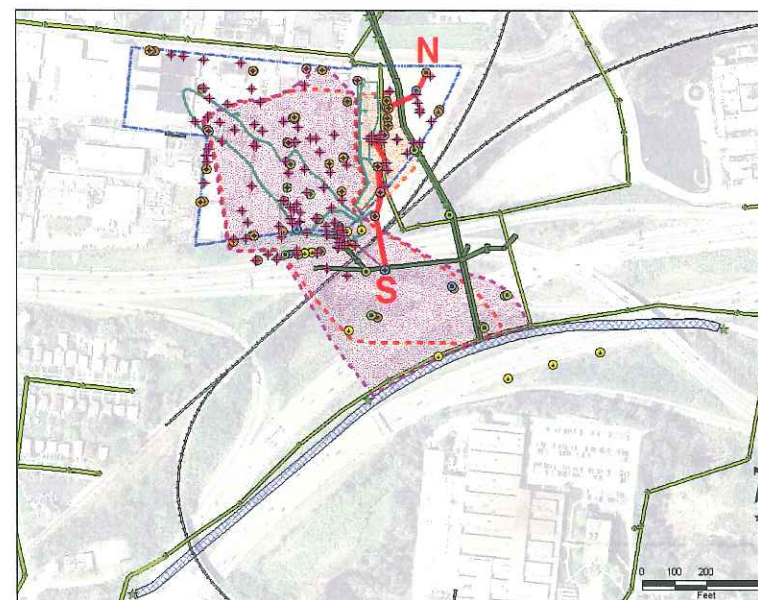


Figure 4-3

North-South Cross Section with Railroad Fill

Conceptual Model of Current Conditions

EMD Chemicals Inc., Cincinnati, OH

Figure Prepared by The Payne Firm, Inc.

LEGEND

- MW1 P6 ○ MONITORING WELL OR PIEZOMETER LOCATION
- (VZ) + VADOSE ZONE SOIL BORING DRILLED BY HOLLOW-STEM AUGER
- (VE) + VERTICAL EXTENT BORING DRILLED BY HOLLOW-STEM AUGER
- (VZB) ● VADOSE ZONE BACKGROUND BORING DRILLED BY HOLLOW-STEM AUGER
- (VZB) ■ APPENDIX IX VADOSE ZONE BORING DRILLED BY HOLLOW-STEM AUGER
- (VZ) ▲ 0 - 2 FT. SOIL BORING
- (LT) * LOWER TILL BORING DRILLED BY HOLLOW-STEM AUGER
- (LT) * LOWER TILL BORING DRILLED BY ROTASONIC
- (VE) + VADOSE ZONE AND VERTICAL EXTENT COMBINATION BORING DRILLED BY ROTASONIC
- (VZ/VE) + APPENDIX IX VADOSE ZONE AND VERTICAL EXTENT COMBINATION BORING DRILLED BY HOLLOW-STEM AUGER AND ROTASONIC
- (VZ) + VADOSE ZONE BORING DRILLED BY ROTASONIC
- B51 ● PRE-R/F/S SOIL BORING
- POORLY GRADED GRAVEL WITH SILT AND CLAY
- SILTY CLAY WITH GRAVEL
- COARSE SAND AND GRAVEL
- SILT TO VERY FINE SAND
- LINE DIVIDES COARSER GRAINED DEPOSITS FROM FINER GRAINED DEPOSITS

APPROXIMATE SCALE: 1" = 100'

Figure 4-5
Lower Clay Unit Erosional Features
Conceptual Model of Current Conditions
EMD Chemicals Inc., Cincinnati, OH
Figure Prepared by The Payne Firm, Inc.

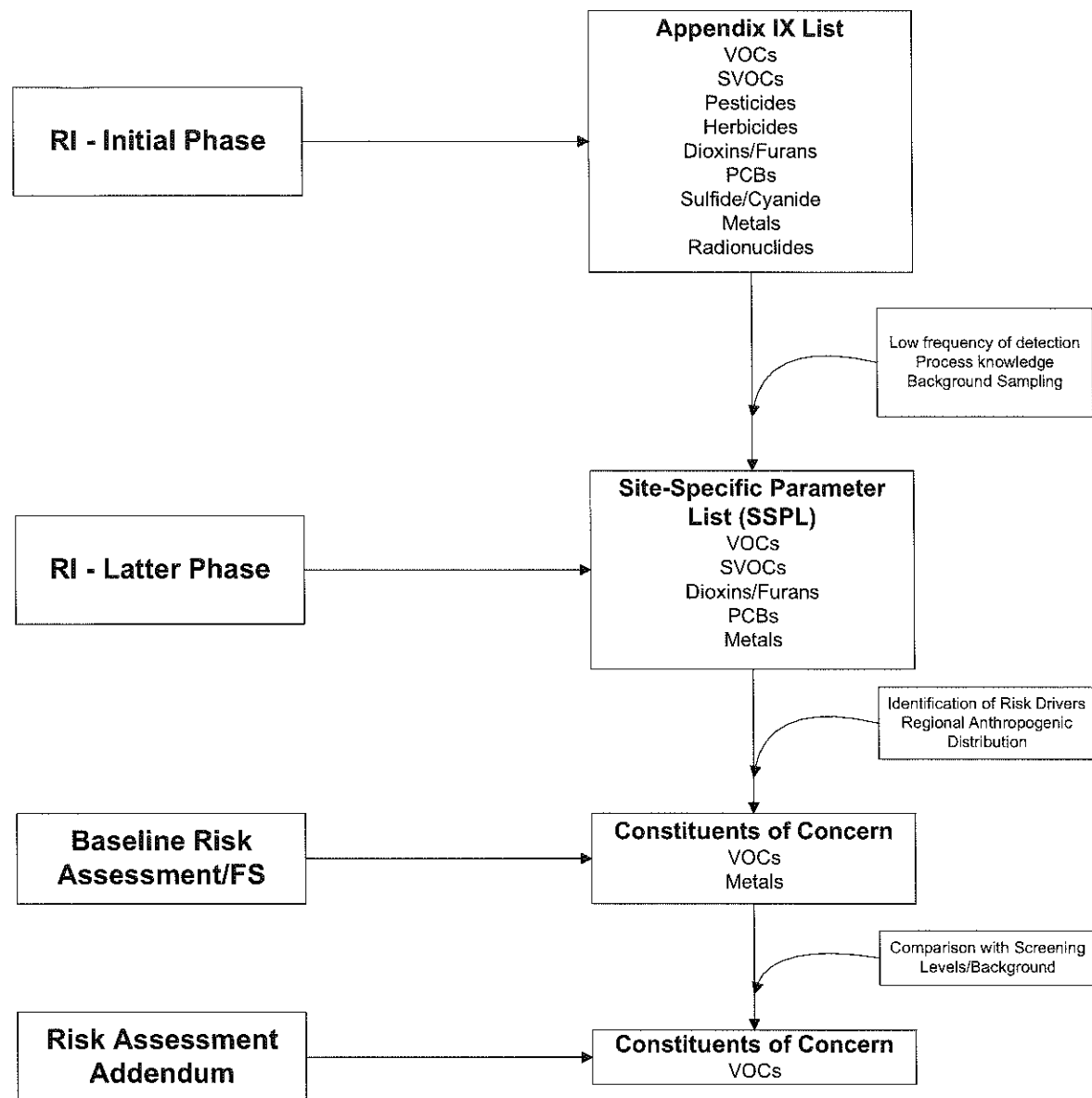


Figure 4-7

**Site Specific Parameter List Development
Conceptual Model of Current Conditions
EMD Chemicals Inc., Cincinnati, OH
Figure Prepared by The Payne Firm, Inc.**